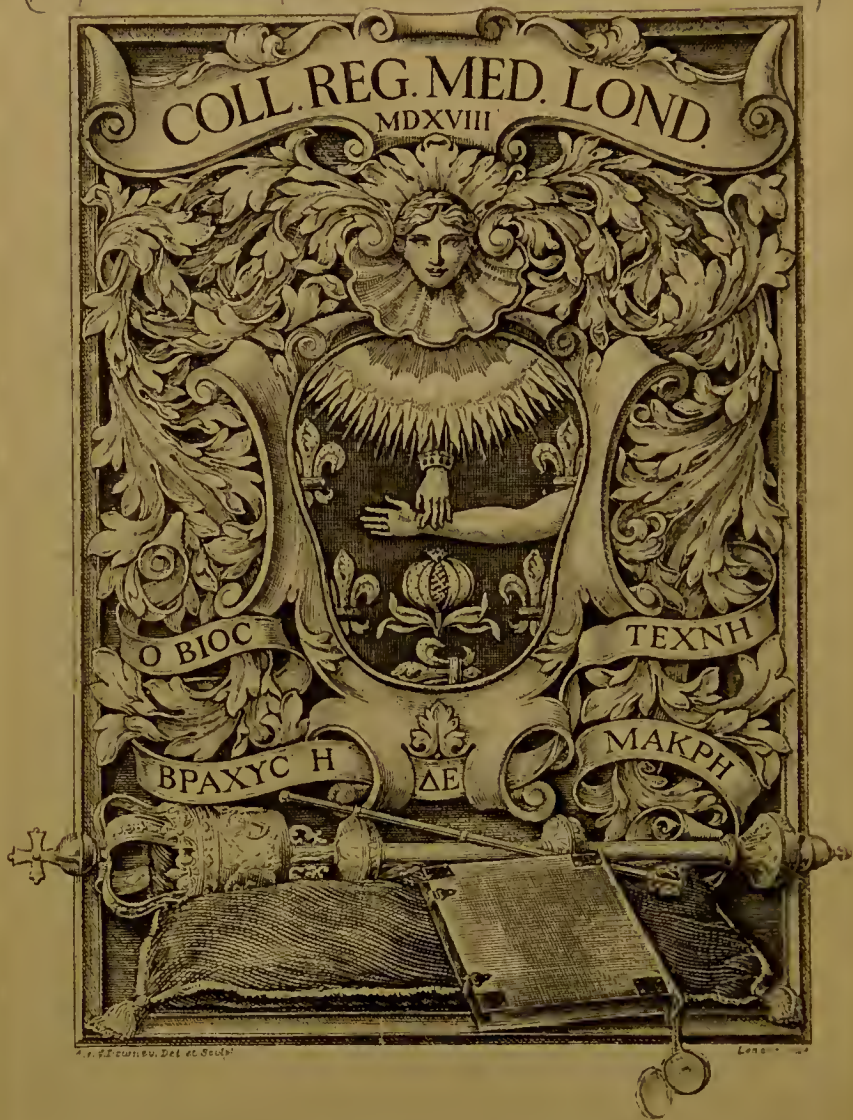


The Gift of Dr. G. A. Auden, F.R.C.P.
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E L E M E N T S

O F T H E

Theory and Practice

O F

C H Y M I S T R Y

T R A N S L A T E D

From the French of M. MACQUER.

Member of the Royal Academy of Sciences, and Professor of Medicine in the University of Paris.

I N T W O V O L U M E S.

V O L. II.

T H E F O U R T H E D I T I O N.

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C O N T E N T S

O F V O L. II.

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E L E M E N T S

OF THE

PRACTICE OF CHYMISTRY.

PART I. SECTION III.

Of Operations on the SEMI-METALS.

C H A P. I.

Of ANTIMONY.

P R O C E S S. I.

To separate Antimony from its Ore by Fusion.

HAVING drilled some small holes, of about two lines diameter, in the bottom of a crucible, put into it your Antimonial ore broken into little bits, about the size of a hazel nut; lute on its cover; set the crucible thus prepared in the mouth of another crucible, and close the joints with lute.

At the distance of half a foot from this compound vessel place bricks all round, so as to form a furnace; the sides of which must rise as high as the brim of the uppermost crucible.

Let the bottom of this furnace be filled with ashes, up to the top of the lower crucible, and the rest of

the furnace with lighted coals. Blow the fire, if it be necessary, with bellows, till the upper crucible become red. Keep it up in this degree for about a quarter of an hour. Then take your vessels out of the furnace, and you will find the Antimony collected in the bottom of the lower crucible, having run through the holes of the upper one.

OBSERVATIONS.

THE ore of Antimony is one of the most fusible: it always contains a great deal of Sulphur, and cannot sustain a fire of any force without being dissipated into vapours. It requires no additament to flux it: for it is not necessary, on this occasion, that the earthy and stony matters mixed therewith be brought to fusion. It is sufficient that the Antimonial part be melted; which, as soon as it becomes fluid, is carried by its weight to the lower part of the crucible. Thus it is separated from all heterogeneous matters; which are left in the upper crucible, while it passes through the holes in its bottom, and forms a mass in the lower.

The precaution of closing all the apertures of both crucibles is necessary, on account of the volatility of this mineral: and that the Antimony, when once melted, may not continue exposed to a great heat, it is made to run down into a vessel surrounded with ashes only, and by that means very little affected with heat; ashes being one of those solid mediums that transmit least of it.

PROCESS II.

The common Regulus of Antimony,

REDUCE crude Antimony to powder. Mix it with three fourths of its weight of white Tartar, and half its weight of refined Salt-petre, both pulverized. Into a large crucible made red-hot

hot in the fire, throw a spoonful of your mixture, and cover it. There will be a very considerable detonation. When it is over, throw in a second spoonful of your mixture, and cover the crucible as before: this will produce a second detonation. Go on thus, till you have thrown in all your mixture.

When the whole has thus fulminated, increase the fire so as to bring the matter into fusion; that being done, take the crucible out of the furnace, and immediately pour its contents into an iron cone heated and greased with tallow. Strike the floor and the cone some gentle blows with a hammer, to make the Regulus precipitate; and when the matter is fixed and cold, invert the cone and turn it out. You will see it consist of two distinct substances; the uppermost of which is a saline scoria, and the undermost the reguline part. Strike this mass a blow with a hammer, in the place where these substances join, and you will by this means separate the scoria from the Regulus; the latter of which will have the form of a metallic cone, on whose base you will observe the signature of a bright star.

OBSERVATIONS.

ANTIMONY, though separated by a former fusion from the earthy and stony parts of its ore, must nevertheless be still considered as an ore, on account of the great quantity of Sulphur it contains, which mineralizes the metalline part or Regulus. Therefore if you desire to have this Regulus pure, you must separate it from the Sulphur that is combined with it. This may be done several ways. The method above proposed is one of the readiest and easiest, though not altogether free from inconveniencies, as we shall shew.

The Salt-petre in the mixture detonates by means of the Sulphur of the Antimony, which it consumes, and from which it separates the regu-

line part : but lest it should also consume some of the phlogiston which gives the Regulus its metalline form, Tartar is added ; because it contains a great deal of inflammable matter, and so is capable of furnishing enough for the detonation of the Nitre, or rather for restoring to the metallic earth of the Antimony the phlogiston that may be consumed by the Nitre.

If we consider what passes in this operation we shall soon be convinced that a great deal must be lost in it, and that we do not thereby obtain near the whole of the Regulus that the Antimony is capable of yielding : for 1. the Regulus of Antimony being a volatile substance, much of it must be dissipated during the detonation ; and so much the more as the detonation is frequently repeated, and continued for a considerable time. The flowers that may be collected by presenting cold bodies to the smoke that rises in the operation, and which may be reduced to a Regulus by the addition of a phlogiston, sufficiently prove what is here advanced.

2. All the Sulphur of the Antimony is not consumed by the Nitre on this occasion ; and moreover, the Acid of that part thereof which is burnt, uniting with some of the Alkali produced by the deflagration of the Nitre and Tartar, forms a Vitriolated Tartar, which meeting with a sufficient quantity of phlogiston in the mixture produces new Sulphur. Now this Sulphur, whether not consumed, or re-produced, in the operation, combining with the Alkali forms a Liver of Sulphur ; and that dissolves part of the Regulus, which by this means remains confounded with the scoria. The proof of this is, that if the scoria be mixed with filings of iron, and fused a second time, you will find at the bottom of the crucible a button of Regulus, which it contained, and which is separated therefrom by the interposition of the Iron.

We

We shall say more on this subject in the process for making the Martial-Regulus, which immediately follows this. If, instead of melting the scoria with iron filings, we pulverize it, boil it in water, and then pour an acid into that water; the liquor will instantly grow turbid, and a Sulphureous Precipitate will fall, commonly called the *Golden Sulphur of Antimony*; which is nothing else but common Sulphur still combined with some particles of the Regulus: a new proof of what we advanced concerning the production of Liver of Sulphur in this operation.

As Regulus of Antimony is of no great value, the loss sustained in this process is seldom regarded. However, we shall have occasion, in the sequel, to point out a method of obtaining this Regulus with less disadvantage.

P R O C E S S III.

Regulus of Antimony precipitated by Metals.

PUT one part of small iron nails into a crucible, and set it amidst burning coals, in a melting furnace. When the iron is thoroughly red-hot, and begins to grow white, add thereto little by little, and at several times, two parts of crude Antimony in powder. The Antimony will immediately flow and unite with the Iron. When the Antimony is entirely melted, add thereto, at several times, the fourth of its weight of pulverized Nitre: a detonation will ensue, and the whole mixture will be in fusion.

After you have kept the matter in this condition for some minutes, pour it into an iron cone, first heated and tallowed. Strike the sides of the cone with a hammer, that the Regulus may fall to the bottom; and, when all is cold, separate it from the scoria by a blow with a hammer. Melt this first

Regulus again in another crucible, adding a fourth part of its weight of crude Antimony. Keep the crucible close shut, and give no more heat than is necessary to melt the matter. When it is in perfect fusion, add to it at several times, as you did before, the sixth part of its weight of pulverized Nitre; and, in half a quarter of an hour after this, pour the whole into a cone as you did the first time.

Lastly, melt your Regulus over again a third or even a fourth time, always adding a little Nitre, which will detonate as before. If after all these fusions you pour the Regulus into an iron cone, you will find it very beautiful, and the star well formed: it will be covered with a semi-transparent, lemon coloured scoria. This scoria is extremely acrid and caustic.

OBSERVATIONS.

THOUGH Regulus of Antimony unites very readily with Sulphur, and is always found combined therewith in the earth, we must not thence conclude that it hath a greater affinity than other substances with that mineral: on the contrary, all the metals, except Gold, have a greater affinity than this Semi-metal with Sulphur. Hence it follows that all the metals, except Gold, are capable of decomposing Antimony, and separating the sulphureous part from the metalline; so that, instead of employing Iron, as in our process, Copper, Lead, Tin, or Silver, may be used, and a Regulus obtained by means thereof.

But as Iron is, of all the metallic substances, that which hath the greatest affinity with Sulphur, it is on this occasion preferred to the rest. And from hence two advantages arise; the first is, that the operation is performed sooner and with greater ease; the second, that the Regulus is purer, and contains less of the precipitating metal. For it

is a general rule; that, when one metallic substance is employed to precipitate another, the precipitated substance is always a little adulterated by the admixture of some particles of the precipitant. Now, the greater affinity the precipitant hath with the matter united to that which is to be precipitated, the less doth the precipitate retain of the precipitant.

In this process the Iron melts very easily by means of the union it contracts with the Sulphur; which, as we observed before, hath the property of rendering this metal very fusible; though of itself the most refractory of all.

The scoria found on the Regulus of the first fusion is a combination of Iron with the sulphureous part of the Antimony. This scoria is extremely hard, and not to be separated from the Regulus without some trouble. The Nitre added, being alkalized and uniting therewith, renders it a little softer, and gives it the property of relenting in the air. Any Alkaline Salt may be substituted for the Nitre.

The Nitre that is alkalized in the operation, or the Alkali that is added, procures moreover another advantage; namely, that, by uniting with part of the Sulphur of the Antimony, it produces a Liver of Sulphur, which dissolves the Iron, retains it, and hinders that which is not yet combined with pure Sulphur from uniting so readily with the Regulus as it otherwise would do.

Lastly, the addition of Nitre, or an Alkali, contributes greatly to promote the fusion, to render it more perfect, and to procure a more complete precipitation of the Regulus.

The second fusion which the Regulus is made to undergo is intended to purify it from any mixture of Iron. When the fresh Antimony added on that occasion comes to melt with the Regulus, the Sulphur contained in the Antimony joins with the ferruginous parts in the Regulus; and the Iron becoming lighter by this union is thrown up to the surface

of the matter. There it forms a sort of scoria, with which a good deal of Antimony is mixed; the Regulus not being wholly precipitated, because there is not Iron enough in the mixture for that purpose. The Salt-petre added here produces the same effect as in the first fusion.

But if, on one hand, the Regulus precipitated in the first fusion be purified, by this addition of fresh Antimony, from most of the Iron with which it was alloyed; on the other hand this same Regulus cannot be kept from re-uniting with some sulphureous parts.

In order therefore to separate it entirely from these, it must be melted over again once or twice more, and a little Nitre added each time, to consume them by deflagration. But this cannot be done without consuming also some of the very phlogiston which gives the Regulus its metalline form: whence it comes to pass that part of the Regulus is converted to a calx, which by means of the alkalinized Nitre is turned into glass; and it is this glass which mixing with the scoria gives it the yellow colour observed therein. This yellow colour may also be in part produced by some ferruginous particles, of which a small quantity always remains combined with the Regulus, notwithstanding its former depuration by Antimony.

It is of no use to repeat the fusions of the Regulus oftener than is above proposed, or to add fresh Nitre with a view to consume the Sulphur it may still contain: for after the second fusion it contains none at all, and retains only the phlogiston necessary to give it the metalline form. So that, by prosecuting the matter further, you would only calcine and destroy the Regulus to no manner of purpose.

From what hath been said it is plain that, even by this process, we do not obtain all the Regulus which our Antimony is capable of yielding; seeing part of it is destroyed by the fusions it must necessarily

asily undergo with Nitre, in order to its purification. We shall give a process for obtaining from Antimony the greatest quantity of Regulus it can possibly be made to yield, after we have treated of its Calcination, which is in some sort the first step of that process.

P R O C E S S IV.

The Calcination of Antimony.

TAKE an unglazed earthen vessel, wider at top than at bottom; put into it two or three ounces of crude Antimony finely pulverized. Set this vessel over a weak charcoal-fire, and increase the heat till you see the Antimony begin to smoke a little. Continue the fire in this degree, and keep incessantly stirring the Antimony with the shank of a tobacco pipe all the while it is upon the fire.

The powder of Antimony, which, before calcination, was of a brilliant colour inclining to black, will become dull, and look like an earth. When it comes to have this appearance raise your fire till the vessel be red-hot, and keep it up in this degree till the matter cease entirely to smoke.

O B S E R V A T I O N S.

ANTIMONY, as hath been already said, is a sort of ore consisting of a metalline or reguline part mineralized by Sulphur.

The design of this calcination is, by the action of fire, to dissipate the sulphureous part, which is the most volatile, in order to separate it from the metalline part. It is evidently a real torrefaction; but the operation is very difficult, and requires a good deal of attention: for Antimony very easily melts, while at the same time it is necessary to our success that it do not melt; because when the matter is in
fusion

fusion the Sulphur requires a much greater degree of heat to carry it off. Now, as Regulus of Antimony itself is very volatile, a good deal of it would be dissipated along with the Sulphur, if it were exposed to the degree of heat necessary to carry off the Sulphur when the mass is melted.

Therefore if it happen that the Antimony begin to melt during the calcination, which is easily perceived by its running into clots, it must be taken off the fire, and the clotted parts be again pulverized; after which the calcination is to be prosecuted with a less degree of heat.

When the Antimony has lost all its brightness, and is become like an earth, it is time to augment the degree of heat, in order to complete the calcination; because the last portions of the Sulphur are the most difficult to raise. Moreover, the inconveniences just mentioned are not now to be apprehended: for, as the great fusibility of the reguline part is owing to the Sulphur, what remains, after you have dissipated the greatest part of the Sulphur, is much less fusible; and, as the redundant Sulphur of the Antimony cannot be driven off, without dissipating at the same time a good deal of the phlogiston necessary to metallize its Regulus, the matter that remains comes much nearer to the nature of a calx, than to that of a metalline substance; and consequently partakes of the nature of all metallic calxes, which is to be very fixed.

Antimony may also be calcined by mixing with that mineral an equal quantity of charcoal-dust. As charcoal is incapable of fusion, it prevents the Antimony from clotting, as well as from losing so much of its metallizing phlogiston as it otherwise would: and hence it comes to pass that the calx of Antimony, prepared in this manner, comes nearer to the nature of a Regulus, than that which is prepared without addition.

If

If you happen to raise the fire too much, in this calcination with charcoal-dust, the calx will be partly reduced to a Régulus, by means of the phlogiston which the charcoal furnishes; and then the Régulus will be dissipated in vapours, especially as this calx, which comes very near the nature of a Régulus, is not so fixed as that prepared without addition. For this reason it always continues to smoke, even when it contains no superfluous Sulphur: and therefore you must not wait till it cease to smoke before you put an end to your calcination; for you will lose a great deal of it in vapours. It is time to stop when the vapours that rise from it, while it is moderately red, do not smell of burning Sulphur.

PROCESS V.

Calx of Antimony reduced to a Régulus.

MIX the calx of Antimony, which you intend to reduce, with an equal quantity of black soap. This mixture will make a thin paste. Put it little by little into a crucible, previously made red-hot amidst live coals. Thus let the soap burn till it cease to emit any oily smoke. Then cover the crucible; make the fire strong enough to melt the matter, and you will hear it effervesce and boil. When this noise is over let the crucible cool, and then break it: you will find in it a beautiful scoria, marked with circles of several colours; and under that a button of Régulus, which is not yet quite pure, and must be purified in the following manner.

Pound this Régulus, and mix it with half its weight of an antimonial calx as perfectly desulphurated as possible. Put it into a crucible, and cover it: melt the whole, so that the surface of the melted matter may be smooth and uniform. Let the crucible

cible cool, and then break it : you will find in it a beautiful button of very pure Regulus, covered with a scoria having the appearance of an opaque glass, or a kind of greyish enamel, moulded on the finely radiated surface of the Regulus.

OBSERVATIONS.

OF all the metalline calxes that of Antimony is most easily reduced. Any matter that contains the phlogiston, even charcoal-dust alone is sufficient to procure it the form of a Regulus, without the addition of any thing to facilitate its fusion ; because this calx, which is not of itself altogether refractory, becomes still more fusible as it combines with the phlogiston, and approaches to the reguline state.

Though all inflammable matters are capable of procuring the reduction of the calx of Antimony, yet there are some with which the operation succeeds better, and produces a greater quantity of Regulus, than it does with others. Fatty matters, joined with Alkalis, are those which answer best in this reduction, as they do in most others. The black flux, for instance, is very proper for this purpose : but Mr. Geoffroy, who made many experiments on Antimony, found by repeated trials that black soap is still fitter for it, and that a greater quantity of Regulus was obtained by its means, than by any other reducing flux whatever. The process here given is taken from one of the Memoirs on this subject, which he laid before the Academy of Sciences.

Black soap is made of the lye of a fixed Alkali, such as pot-ash for instance, with quick-lime, incorporated by boiling with oil of lint-seed, rape-seed, or hemp-seed, and sometimes also with animal fat. The oily matters, contained in this reducing flux, are first burnt and charred to a coal in the crucible. As soon as they are brought to this state, the
crucible

crucible is covered, and the fire is encreased, till the matters melt. At that instant the reduction begins to take place; and the bubbling noise observed is an effect thereof.

The Regulus obtained by this first fusion is not yet very pure, being adulterated with the mixture of some unmetallic earth that was contained in the Antimony, and with a portion of the calcarious earth of the soap.

Mr. Geoffroy found that his Regulus was contaminated with this substance, by putting it into water: for on that occasion he observed a very brisk ebullition about the reguline buttons, which sometimes lasted above four and twenty hours; and on examining them with a glass, he discovered some little holes, imperceptible to the naked eye, through which the water entered, to unite with the lime retained in the internal parts of the Regulus, which having been re-calcined in the operation required to be slaked.

This Regulus may be purified by simple fusion, without any additament, because the particles of lime, being lighter than those of the Regulus, will be thrown up to the surface, on which they will form a sort of scoria. But Mr. Geoffroy took notice that, in this case, the surface of the Regulus is never very neat; that it is always sullied with a very adhesive scoria, and that no star is formed upon it. Besides, the Regulus must be kept a long while in very thin fusion, that the heterogeneous matters, which hinder the perfect re-union of its parts, may have time to rise to the surface by their lightness. But the longer the Regulus is kept in fusion, the more of it evaporates, because of its volatility. He was therefore obliged to have recourse to other means.

We have in the process described the method which succeeded best with Mr. Geoffroy. It consists

sists in melting the Regulus over again, with the addition of a little fresh calx of Antimony thoroughly freed from its Sulphur. This calx being in its nature easily vitrifiable, and combining with the earthy parts that deprave the Regulus, and which cannot be vitrified without addition, scorifies these matters, and with them forms the opaque glass, or kind of enamel which is found over the Regulus purified in this manner.

The star on that part of the Regulus of Antimony, which was contiguous to the scoria, is a mark of its purity, and a proof that the operation was well performed. This star is nothing but a particular disposition of the parts of the Antimony, which have the property of running naturally into facets and needles. The perfect fusion, both of the Regulus and the scoria that covers it, leaves the parts of the Regulus at liberty to range themselves in this order. This disposition appears not only on the upper surface of the Regulus, but, if you break the button, you find the same in its internal parts. There are some round pyrites whose insides have nearly the same appearance, and seem to consist of rays issuing from a common center.

The quantity of Regulus obtained by Mr. Geoffroy's process is more than double of what is procured in the common way, which yields but about four ounces in the pound; whereas this gives from eight to ten ounces.

When Antimony is calcined with charcoal-dust, what remains after the dissipation of all the Sulphur is not, properly speaking, a calx of Antimony; but a sort of Regulus quite formed, and differing from the common Regulus only in that its parts are disunited, and not collected into a mass. For if this pretended calx of Antimony be melted, it directly coalesces into a Regulus, without the addition of any inflammable matter fit to procure its reduction.

tion. Indeed less Regulus is obtained by this means than when a reductive is added : but nevertheless this experiment still proves what I advanced ; seeing Regulus of Antimony cannot be melted without losing more or less thereof, either because some of it is dissipated in vapours, or because part of it loses its phlogiston in the fusion, and so is converted into a calx.

P R O C E S S VI.

*Antimony calcined with Nitre. Liver of Antimony.
Crocus Metallorum.*

PULVERIZE and mix perfectly together equal parts of Nitre and Antimony : put the mixture into an iron mortar, and cover it with a tile, which however must not shut it quite close. With a live coal set fire to the matter in the mortar, and immediately withdraw it. The mixture will flame, with great detonation ; which being over, and the mortar cooled, invert it, and strike its bottom to make all the matter fall out. Then, by a blow with a hammer, separate the scoria from the shining part, which is the *Liver of Antimony*.

O B S E R V A T I O N S.

IN this operation the Nitre takes fire and detonates with the Sulphur of the Antimony ; and nothing remains but the metallic earth of the mineral, which, meeting with no substance to restore its phlogiston, cannot take the form of a Regulus ; but, being combined with a large quantity of fused saline matters, begins itself to flow, and forms a sort of vitrification ; which however is not a complete one, because the matters do not continue long enough in fusion, but cool too soon. This preparation

ration of Antimony is a violent Emetic. It is used to make Emetic Wine and Tartar Emetic: it is also given in substance to horses.

The saline matters found after the operation in the form of a scoria, or perhaps confounded with the Liver of Antimony, are combinations of Fixed Nitre, partly with the Acid of the burnt Sulphur, forming a Neutral Salt of the same kind as Vitriolated Tartar, and partly with some unburnt Sulphur, forming a sort of Liver of Sulphur that contains a little Regulus. It is usual to pulverize this Liver of Antimony and wash it with water, in order to dissolve and carry off all the Salts. When thus pulverized and washed it is called *Crocus Metallorum*. If Liver of Antimony be melted with any inflammable matter, it will be reduced to a Regulus; because it is nothing but a metalline calx half vitrified.

PROCESS VII.

Another Calcination of Antimony with Nitre. Diaphoretic Antimony. Materia Perlata. Clyffus of Antimony.

MIX one part of Antimony with three parts of Nitre; project this mixture by spoonfuls into a crucible kept red-hot in a furnace. Each projection will be attended with a detonation. Continue doing this till you have used all your mixture: then raise the fire, and keep it up for two hours; after which throw your matter into a pan full of hot water. Let it lie steeping in water kept hot for a whole day. Then pour off the liquor: wash the white powder you find at bottom in warm water; and repeat the ablutions till the powder become insipid. Dry it, and you have *Diaphoretic Antimony*.

OBSERVATIONS.

THIS operation differs from the preceding one, in respect of the quantity of Nitre deflagrated with the Antimony. In the former we added one part only of Nitre to one part of Antimony; but in this three parts of Nitre are put to one of the mineral; and the calx resulting from this mixture is of course very different from the other.

In the first place, Liver of Antimony hath a reddish colour; whereas Diaphoretic Antimony is very white. Secondly, Liver of Antimony is in a manner half vitrified; Diaphoretic Antimony is, on the contrary, in the form of a powder, the parts of which have no connection together.

The reason of these differences will easily appear, if we consider, that, Liver of Antimony being the result of calcination with one part of Nitre only, which is not sufficient to consume all the Sulphur of the mineral, what remains after the detonation is not entirely deprived of its phlogiston; from whence arise the colour it retains and the ease with which it flows in the fire: but that, when three parts of Nitre are added instead of one, this quantity is not only sufficient to consume all the Sulphur and the phlogiston of the Antimony, but even more than enough; seeing that, after the operation, some Nitre is still found undecomposed.

The calx of Antimony, prepared by calcining it with three parts of Nitre, is therefore deprived of all its phlogiston. This is the cause of its whiteness, and the reason why it is not half vitrified by the operation, as Liver of Antimony is: for we know that the more a metallic calx is deprived of its phlogiston, the less fusible and the less vitrifiable it is. This calx of Antimony bears the name of *Diaphoretic Antimony*, or *Diaphoretic Mineral*; because, being neither emetic nor purgative, it is

thought to have the virtue of promoting perspiration.

Antimony may be calcined with various proportions of Nitre, between that used to make Liver of Antimony, and this with which Diaphoretic Antimony is prepared; and from these calcinations will result calxes possessed of properties, both chymical and medical, of an intermediate nature between the extremes of those two preparations. The nearer the proportion of Nitre comes to that employed in preparing Liver of Antimony, the more will the resulting calx resemble that preparation; and in the same manner, a calx prepared with a greater proportion of Nitre will so much the more resemble Diaphoretic Antimony, as the proportion of Nitre used comes nearer three parts of Nitre for one of Antimony.

It is not necessary that Antimony in substance be employed to make the Diaphoretic Mineral: you may, if you please, make use of its Regulus. But as the Regulus contains no Sulphur, nor any more phlogiston than is requisite to secure its metalline form, it is needless to put three parts of Nitre to one of Regulus; an equal quantity thereof being sufficient.

The matter is projected by spoonfuls, to the end that, by gradual and repeated detonations, the Antimony may be more perfectly calcined: it is also with a view to destroy entirely the small remainder of phlogiston, which may have escaped the action of the Nitre, that the matter is kept red-hot in the crucible for two hours.

The whole is afterwards thrown into hot water, and left steeping therein for several hours, with design to give the water time to dissolve all the saline matters that are mixed with the Diaphoretic Calx. When crude Antimony is used in making this preparation, these saline matters are, 1. an Alkalized Nitre; 2. a Neutral Salt formed by

by the union of the Acid of Sulphur with part of that Alkali, as in the preparation of Liver of Antimony; 3. a portion of undecomposed Nitre.

The water in which the Diaphoretic is washed takes up moreover a portion of the calx of Antimony, which is exceeding finely attenuated, and continues united with the Fixed Nitre, and suspended therewith in the liquor. This matter is to be separated from the Fixed Nitre, by mixing the water wherein it is dissolved with an Acid, which unites with the Alkali, and precipitates this matter in the form of a white powder, to which the name of *Materia Perlata* hath been given. Because it is precipitated in the same manner as the Golden Sulphur of Antimony, and, like that, is found in the water with which the saline matters are washed out, after the detonation of Nitre with Antimony, some Chymists have given it, though very improperly, the name of the *Fixed Sulphur of Antimony*.

This matter is a true Calx of Antimony, and differs from Diaphoretic Antimony in nothing but its being still more perfectly calcined. It is so indeed to such a degree that it is impossible to restore its metalline form, or reduce it to a Regulus, by the addition of an inflammable matter. Diaphoretic Antimony, on the contrary, may be re-metallized, by supplying it with phlogiston: but it must be observed that, in whatever manner you go about this, you will obtain a much smaller quantity of Regulus, than when you use a Calx of Antimony prepared with a smaller quantity of Nitre.

If you attempt to reduce either Liver of Antimony or Diaphoretic Antimony, great care must be taken to wash them thoroughly, in order to free them from every thing saline: for, without this precaution, the Acid of the Sulphur, having, as was observed, formed a Neutral Salt with the Alkali of the Nitre, will combine with the inflam-

mable matter added to re-vivify the calx of Antimony and re-produce a Sulphur; which, uniting afterwards with the same Alkali, will produce a Liver of Sulphur, that will dissolve part of the Regulus, hinder its precipitation, and greatly lessen the quantity which might otherwise be expected.

A particular sort of Diaphoretic Antimony is sometimes prepared for Medical uses, which hath a purgative quality: it is not washed at all, and is therefore called *Unwashed Diaphoretic Mineral*.

Diaphoretic Antimony may also be prepared in close vessels, by means of which the vapours that rise during the operation are retained. For this purpose a tubulated retort is employed, having a series of adopters fitted to it. The retort is placed in a furnace, and heated till its bottom become red: then a very small quantity of the mixture, for making Diaphoretic Antimony, is introduced through the tube in the upper part of the retort, and the tube immediately stopped. A detonation ensues, and the vapours expand themselves into the adopters, where they condense. This is repeated till the intended quantity of matter be used. After the operation some white flowers are found sublimed in the neck of the retort, and a small quantity of liquor in the recipients. This liquor is acid. It consists of some of the Acid of the Nitre, which the Acid of the Sulphur hath expelled from its basis, and also a little of the Acid of the Sulphur carried up by the heat before it could combine with the basis of the Nitre. This liquor is called *Clyffus of Antimony*. The name of *Clyffus* is given to all liquors in general that are prepared by this method.

The white flowers found in the neck of the retort are flowers of Antimony; that is, a calx of Antimony forced up by the heat, and by the impetus of the detonation. These flowers may be reduced to a Regulus. What remains in the retort

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is the same with the matter that remains in the crucible, wherein the mixture of Nitre and Antimony for making Diaphoretic Antimony hath been deflagrated.

Neither Diaphoretic Antimony nor the Pearly matter are soluble in any Acid.

PROCESS VIII.

Calx of Antimony Vitrified.

TAKE any quantity you please of calx of Antimony, made without addition; put it into a good crucible, which set in a melting furnace: kindle the fire gradually, and leave the crucible uncovered at the beginning.

A quarter of an hour after the matter is red-hot, cover the crucible, and excite the fire vigorously till the calx melt. You may know when it is thoroughly melted, by dipping into the crucible an iron wire, to the end of which a little knob of glass will adhere, if the matter be in perfect fusion. Keep it in fusion for a quarter of an hour, or rather longer if your crucible can bear it. Then take it out of the furnace, and immediately pour out the melted matter on a smooth stone, made very hot for the purpose: it will presently fix into a yellow glass.

OBSERVATIONS.

ALL the calxes of Antimony, when exposed to a violent fire, are converted into Glass; but not all with the same facility. In general, the more of their phlogiston they have lost in the calcination, the more difficult is their vitrification. This causes also a difference in the colour of the Glass; which will be of so much a deeper yellow, and the nearer to a red, the less the Antimony was calcined.

It frequently happens, when we employ a calx of Antimony which is not sufficiently deprived of its phlogiston, that we find in the crucible a button of Regulus, which being heavier than the Glass always lies at the bottom. With a view to avoid this inconvenience, and to dissipate completely the excess of phlogiston that may still be left in the calx of Antimony, we direct the crucible to be left uncovered for some time, at the beginning of the operation. If, notwithstanding this precaution, any Regulus be still found at the bottom of the crucible, and you resolve to vitrify it, the crucible must be returned to the furnace, and the fusion continued; by which means the Regulus will at last be converted into Glass.

If, on the contrary, you meet with any difficulty in effecting the vitrification, on account of your having employed a calx that hath lost too much of its phlogiston, such as Diaphoretic Antimony, or the Pearly matter, the fusion may be greatly facilitated by throwing into the crucible a little crude Antimony.

Glass of Antimony is a most violent Emetic. This Glass, as well as Liver of Antimony, is employed in preparing Emetic Wine and Emetic Tartar.

It may be re-suscitated, like the calxes of Antimony, into a Regulus, by re-uniting it with a phlogiston. For this purpose it must be finely pulverized, thoroughly mixed with some black flux, and melted in a covered crucible. This Glass, as well as that of Lead, hath the property of greatly promoting the vitrification of matters that are to be scorified.

PROCESS IX.

Kermes Mineral.

BREAK any quantity you will of Hungarian Antimony into little bits : put it into a good earthen coffee-pot : pour on it twice its weight of rain-water, and a fourth part of its weight of well filtered liquor of Nitre fixed by charcoal. Boil the whole briskly for two hours, and then filter the liquor. As it cools it will acquire a red colour, grow turbid, and leave a red powder on the filter.

Return your Antimony into the coffee-pot. Pour on it as much rain-water as before, and three fourths of the former quantity of the liquor of Fixed Nitre. Boil it again for two hours, and then filter the liquor. It will again deposite a red sediment. Return your Antimony into the coffee-pot : pour on it the same quantity of rain-water, and half the first quantity of the liquor of Fixed Nitre. Boil it again for two hours, and filter the liquor as formerly. Wash all these sediments with warm water, till they become insipid ; then dry them, and you have the *Kermes Mineral*.

OBSERVATIONS.

IF you recollect what we said concerning the property which Fixed Alkalis possess of uniting with Sulphur, both by fusion, and, when those Salts are resolved into a liquor, by boiling, and of forming therewith a Liver of Sulphur, which dissolves all metalline substances, you will readily comprehend the nature of this Kermes.

Antimony consists of a sulphureous and a reguline part. Therefore, if this mineral be boiled in a solution of a Fixed Alkali, such as Nitre fixed by charcoal, the Alkali will dissolve the Sulphur of the Antimony, and form therewith a Liver of Sulphur ; which in its turn will dissolve the reguline part.

Now, Kermes Mineral, prepared as above directed, is no other than a Liver of Sulphur combined with a certain quantity of Regulus of Antimony.

Mr. Geoffroy hath set this truth in the clearest light, by his accurate analysis of the Kermes Mineral. The experiments he made on that subject are circumstantially related in several Mémoires printed in the volumes of the Academy for 1734 and 1735. By combining Acids with the Kermes he demonstrated, 1. the existence of Sulphur in this compound; having separated from it a burning Sulphur, which cannot be mistaken for any other than the Sulphur of Antimony. In order to obtain this Sulphur pure, an Acid must be employed that will not only absorb the Alkali, but also perfectly dissolve the reguline part that might otherwise remain united with the Sulphur. *Aqua Regia* was the Acid which succeeded best with Mr. Geoffroy. 2. He also proved that there is a Fixed Alkali in the composition of the Kermes; seeing the Acids with which he precipitated the Sulphur became Neutral Salts, and just such as those very Acids combined with a Fixed Alkali would have constituted: that is, the Vitriolic Acid produced a *Sal de duobus*; the Nitrous Acid a regenerated Nitre; and the Marine Acid a regenerated Sea-salt. 3. Mr. Geoffroy demonstrated the reguline part of Antimony to be an ingredient in the Kermes; having procured therefrom an actual Regulus of Antimony, by fusing it with the black flux.

In preparing the Kermes it is necessary to renew the liquor from time to time, as above directed; because, when it is once impregnated with Kermes to a certain degree, it can take up no more; and consequently the same liquor cannot operate again on the Antimony. Experience hath shewn, that, if the doses above prescribed be applied, the liquor will after two hours boiling be sufficiently saturated with Kermes.

If the liquor in which the Kermes is dissolved be filtered while it is very hot, and almost boiling, it leaves nothing on the filter; the Kermes passing through with it: but as it cools it grows turbid, and gradually deposits the Kermes. Therefore it ought not to be filtered till it be cold; or, if it be filtered while it is boiling hot, in order to separate from it some coarse particles of Antimony not yet converted into Kermes, it must be filtered a second time when it is cold, in order to get the Kermes.

Though in the method usually practised for making Kermes, the Antimony is boiled only thrice, yet it does not follow that more Kermes may not be obtained from it, or that but little more would be obtained by a fourth and fifth boiling: on the contrary it would yield considerably more. Mr. Geoffroy observed that he got more Kermes by the second boiling than by the first, and still more by the third than by the second; and that the yield goes on increasing in this manner to a very great number of times, which he hath not determined. This increased effect arises from hence, that by multiplying the frictions of the little bits of Antimony against each other, new surfaces are exposed to the action of the Alkaline liquor, and furnish it with more Sulphur; while the addition of this Sulphur renders the hepar more active and more penetrating; or, if you please, produces a new hepar every time the matters are boiled. When the Alkaline liquor is once saturated with Kermes, it ceases to act, and forms no new hepar; but it doth not follow that its virtue is quite exhausted. To restore its ability of acting as well as at first, or nearly so, you need only let it cool, and deposite the Kermes dissolved in it. We owe this singular observation also to Mr. Geoffroy: he had the patience to go through no less than three-score and ten boilings with the same liquor, without adding any thing but rain-water to supply the place
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of what was dissipated by evaporation; and he always obtained a pretty considerable quantity of Kermes by each boiling, for the reason given above.

Boiling is not the only means of making Kermes. Mr. Geoffroy found the way of making it by fusion. For this purpose you must mix accurately one part of very pure Fixed Alkali, dried and pulverized, with two parts of Hungarian Antimony also pulverized, and melt the mixture. Mr. Geoffroy made use of a retort. When the mass is melted, it must again be pulverized, while it is still hot, and then put into, and kept in, boiling hot water for an hour or two; after which the liquor, now become saline and antimonial, must be filtered into another vessel filled with boiling water. Every ounce of Antimony treated in this manner yields, by thrice boiling the melted mass, from six drams to six drams and a half of Kermes; which differs from the Kermes made by boiling, only in that it is not quite so soft to the touch, having in every other respect the same qualities.

As Liver of Sulphur is made two different ways, to wit, by boiling and by fusion, and as the Kermes is nothing but a Liver of Sulphur in which the reguline part is dissolved; it follows that Kermes may be made by fusion as well as by boiling. It is necessary to pulverize the melted mass, and to steep it in boiling-hot water for an hour or two, that the water may dissolve and divide it sufficiently to make the Kermes fine and beautiful.

With the same view, that is, to make it finer and more perfect, Mr. Geoffroy orders the water saturated with the Kermes made by fusion, to be received, when filtered, in a vessel full of other boiling-hot water. He observed, that when the liquor impregnated with Kermes cools too fast, the Kermes that precipitates is much coarser. The
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warm solution of Kermes is diffused through the boiling-hot water into which it is filtered, and is thereby enabled to retain its heat so much the longer.

From what hath been said on the nature of Kermes, it plainly appears that there must be a great resemblance between it and the Golden Sulphur of Antimony, obtained from the scoria, either of plain Regulus of Antimony, or of the Liver of Antimony; this Golden Sulphur being no other than a portion of the Antimony combined with the Nitre alkalized during the operation.

Yet there is a difference in the manner of precipitating these two compounds: for the Kermes precipitates spontaneously, on the bare cooling of the water in which it is dissolved; whereas an Acid is employed to precipitate the Golden Sulphur suspended in the water, with which the scoria of the plain Regulus of Antimony, or that of Liver of Antimony, hath been washed. This gives some ground to suspect that the reguline part is not so intimately united with the Liver of Sulphur in the Kermes, as in the scoriæ from which the Golden Sulphur is obtained.

PROCESS X.

Regulus of Antimony dissolved in the Mineral Acids.

COMPOUND an *Aqua Regis* by mixing together four measures of Spirit of Nitre, and one measure of Spirit of Salt: on a sand-bath moderately heated place a matrafs, into which pour sixteen times as much of this *Aqua Regis* as you have Regulus to dissolve. Break your Regulus into little bits; and throw them successively one after another into the matrafs, observing not to add a new one till that put in before is entirely dissolved: continue this till your Regulus be all used. By

degrees, as the dissolution advances, the liquor will acquire a beautiful golden colour ; which, however, will insensibly disappear, as the white fumes that continually ascend from it evaporate.

OBSERVATIONS.

REGULUS of Antimony is one of those metalline substances that dissolve with the greatest difficulty. Not but that most of the Acids attack and corrode it ; but they do not make a clear, limpid solution thereof : they in some sort only calcine it, and this semi-metal, as fast as it dissolves, precipitates of its own accord in the form of a white magistery. In order to effect a complete dissolution thereof, it is necessary to employ an *Aqua Regis* compounded as directed, and in the dose prescribed in the process, which is wholly taken from Mr. Geoffroy's Memoirs on Antimony mentioned above.

If, instead of the Regulus, small bits of crude Antimony be thrown into the *Aqua Regis*, the Acid will attack and dissolve the reguline part, and so separate it from the sulphureous part, which it will not touch. When the dissolution is finished, the particles of Sulphur being now become lighter, because no longer united with the metalline part, will float upon the liquor. Being collected they form a true Sulphur which seems no way different from common Brimstone. This operation, you see, is a sort of Parting Process.

The Vitriolic Acid, whether concentrated or much weakened with water, does not act when cold either on Antimony or on its Regulus. This Acid only dims the splendour of the facets of the Regulus ; but, if one part of exceeding pure Regulus of Antimony be put into a retort, and four parts of clear concentrated Oil of Vitriol poured on it, as soon as the Acid is heated it turns brown, and emits a most suffocating smell of Sulphur, which

which encreases as the Regulus is penetrated and corroded by the Acid.

On raising the fire, there separates from it a matter that seems mucilaginous; and when the Acid hath boiled some time, the Regulus is converted into a white saline mass, as Mercury is in the preparation of Turbith mineral. At the same time a little Sulphur sublimes into the neck of the retort. At last all the Oil of Vitriol passes over into the receiver, and leaves the Regulus in a white, spongy, saline mass in the retort. When the fire is out, the vessels unluted, and the receiver separated from the retort, there rises a white vapour like that of the smoking liquor of Libavius.

The saline mass left in the retort, after the operation, is found increased to near double its weight: this increased weight is owing to the Acid that hath united with the Regulus.

This combination of the Vitriolic Acid with the Regulus of Antimony is excessively caustic, and cannot, for that reason, be administered internally.

The purest Spirit of Salt hath no sensible effect either on Antimony or its Regulus: but if Antimony be coarsely pounded, it separates therefrom, though slowly, some light, sulphureous flakes.

The action of Spirit of Nitre on this metallic substance is more perceptible: by little and little it attacks the plates of the Antimony, which discharge a great number of air-bubbles. As the dissolution advances, the Acid acquires a greenish colour inclining to blue; and if there be not too much of it, it will be almost entirely imbibed by the Antimony, penetrate between its *laminae*, and exfoliate them in the direction of the needles that compose them. If there be too much of the Acid, that is, if it rise above the Antimony, it will destroy these plates, and reduce them to a white powder.

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But when the Acid is imbibed slowly, we discover between the swelled *laminæ* little saline transparent crystals, that vegetate much in the same manner as those of the pyrites, in which small crystals of Vitriol are frequently observed, whose figures are not very well determined. These little crystals between the Antimonial plates are intermixed with yellow particles, which being carefully separated burn like common Sulphur.

All these useful observations, concerning the action of the Acids on Antimony and its Regulus, we owe likewise to Mr. Geoffroy; who advises the collecting a quantity of these little crystals in time; because they disappear soon after they are formed, being probably covered by the white powder, or magistery, which is continually produced as fast as the Nitrous Acid disunites and separates the needle-like fibres of the Antimony.

Mr. Geoffroy observed the same sort of crystals on the Regulus of Antimony, when substituted for crude Antimony in this experiment: but it requires a great deal of care to separate these crystals; for as soon as the air comes into contact with them they lose their transparency; and, if you wait till the Regulus be in some measure converted into a magistery, they are not then to be distinguished.

In order therefore to have a good view of these crystals, the Regulus must be broken to pieces; these pieces put in a glass basin, and Spirit of Nitre poured on them to half their height, but not to cover them. This Acid penetrates them, exfoliates them in white scales; and on the surface of these scales the crystals shoot of a dead-white colour. In two or three days time these crystals vegetate and grow in the form of cauliflowers: they must then be gathered, to prevent their being confounded in the white magistery which continues to be produced, and would not suffer them to be distinguished. If
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you attempt to dissolve the reguline part of Antimony by an *Aqua Regis* compounded in different proportions, and applied in a different dose, from what is prescribed in the process, the Regulus of Antimony will only be calcined, as it is by the other Acids, and will precipitate in the form of a white magistery as fast as it dissolves, so that no part thereof will remain united with the solvent. The proof of this is, that, if an Alkaline liquor be poured, even to the point of saturation, upon the *Aqua Regis* that hath thus dropt the Antimony, no new precipitate will be deposited.

P R O C E S S XI.

Regulus of Antimony combined with the Acid of Sea-salt. Butter of Antimony. Cinabar of Antimony.

PULVERIZE and mix thoroughly six parts of Regulus of Antimony, and sixteen parts of Corrosive Sublimate. Put this mixture into a glass retort that hath a wide short neck, and let one half of its body at least be left empty. Set it in a reverberatory furnace, and having fitted a recipient thereto, and luted the joint, make a very small fire at first, to heat it slowly. Encrease it afterwards by degrees, till you see a liquor ascend from the retort that grows thick as it cools. Keep up the fire to this degree as long as you see any of this matter come over.

When no more rises with this degree of fire, unlute your vessels, take off the receiver, and in its place substitute another filled with water. Then encrease your fire by degrees till the retort be red-hot. Some running Mercury will fall into the water, which you may dry and keep for use; it being very pure.

OBSERVATIONS.

IN our observations on the preceding process we took notice that the purest Marine Acid, in the form of a liquor, will not dissolve the reguline part of Antimony. Here this very Acid combined with Mercury, and applied in a dry form to the Regulus of Antimony, quits the Mercury, with which it was united, in order to join this very Regulus, as having a greater affinity therewith. This operation is a further proof of what we advanced on the subject of Mercury; to wit, that several metallic substances, which are not soluble by certain Acids when in a fluid state, may be dissolved by those Acids when most highly concentrated; as they are when combined with any other substance in a dry form, and are separated from it by the force of fire. Their efficacy is also further promoted by their being reduced, on this occasion, into subtile vapours.

The Marine Acid combined with the reguline part of Antimony doth not form a hard, solid compound; but a kind of soft substance, that melts in a very gentle heat, and also becomes fixed by the least cold, much in the same manner as butter; and from this property it hath its name.

Soon after mixing the Regulus with the Corrosive Sublimate, the matter sometimes grows considerably hot: this is occasioned by the Marine Acid's beginning to act on the reguline part, and to desert its Mercury.

The Butter of Antimony rises with a very moderate heat; because the Acid of Sea-salt hath the property of volatilizing, and carrying up along with it, the metallic substances with which it is combined: and for this reason a very gentle heat only is required at the beginning of the operation.

It is absolutely necessary that the neck of the retort be wide and short: for otherwise if the Butter
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of Antimony should fix and be accumulated therein, it might stop up the passage entirely, and occasion the bursting of the vessels. By this operation we obtain eight parts and three quarters of fine Butter of Antimony, and ten parts of running Mercury; there being left in the retort one part and a half of a rarefied matter, black, white, and red. This is probably the most earthy and most impure part of the Regulus of Antimony.

It is of the utmost consequence to the operator that he avoid with the greatest care the vapours that issue from the vessels, because they are extremely noxious, and may occasion mortal disorders. The Butter of Antimony is a most violent Corrosive and Caustic.

When all the Butter is risen, the receiver is shifted in order to receive the Mercury; which, being disengaged from the Acid that gave it a saline form, appears in its natural form of Quick-silver; but it requires a much greater degree of heat than the Butter of Antimony to raise it by distillation.

If crude Antimony, instead of Regulus of Antimony, be mixed with Corrosive Sublimate, a Butter of Antimony will be obtained in the same manner; but, instead of having a running Mercury after the Butter, you will find a Cinabar sublimed into the neck and upper concavity of the retort.

The reason of this difference is easily conceived: for, when the Regulus is used, the Mercury being deserted by its Acid finds no other substance to unite with, and so rises in the form of Quick-silver; but when crude Antimony is employed instead of its Regulus, as the reguline part thereof cannot combine with the Acid without quitting its Sulphur, so this Sulphur, being at liberty, unites with the Mercury, which is so likewise, and therewith forms a Cinabar; which from its origin is named *Cinabar of Antimony*. When you intend to make both

Butter and Cinabar of Antimony at the same time, six parts of Antimony must be mixed with eight of Corrosive Sublimate; and care must be taken, while the Butter is coming over, to warm the neck of the retort by holding some live coals near it, with the precautions necessary to avoid breaking it. This warmth makes the butter melt and run into the receiver; whereas, being thicker and of a much denser consistence than that made with the Regulus, it would otherwise gather in the neck of the retort, choak it entirely, and burst the vessel.

When the Butter is drawn from crude Antimony, more circumspection is necessary to make it of a beautiful white colour, than when it is obtained from the Regulus: for, if the fire be too strong during the distillation, or if the receiver be not soon enough separated from the neck of the retort, certain red sulphureous vapours, the forerunners of the Cinabar, will at last ascend, and mixing with the Butter give it a brown colour.

In order to restore its beauty it must be put into a clean retort, and rectified by distilling it over again with a gentle sand-heat. By this rectification the Butter of Antimony becomes more fluid; and by re-distilling it a second time you may give it the thinness and fluidity of an oil.

After the operation there will be found in the receiver three parts and three quarters of Butter of Antimony, and some small crystals adhering to its inside, in the form of sprigs. When you break the retort there exhales from it a sulphureous odour; and you will find in it seven parts of Cinabar of Antimony, the greatest part of which is usually in compact glebes, that are heavy, smooth, shining, blackish throughout most of the mass, but in some places red: another part thereof appears in shining needles, and the rest in powder.

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When all the Butter of Antimony is come over, and you begin to see the red vapours that predict the approaching ascent of the Cinabar, the receiver containing the Butter must be removed, lest the colour of the Butter should be spoiled by those sulphureous vapours. Another receiver is usually fitted on, without luting; in which a small quantity of running Mercury is sometimes found, when the operation is finished.

There remains, at the bottom of the retort, a fixed, shining, crystalline, black mass, which may be reduced to a Regulus by the common method.

Butter of Antimony may also be obtained from a mixture of Antimony with any of the other preparations of Mercury in which the Acid of Sea-salt is an ingredient; such as Sweet Sublimate, the Mercurial Panacea, and White Precipitate: but as none of these combinations contain so great a proportion of that Acid as is in the Corrosive Sublimate, the Butter obtained by their means is far from being so caustic and so fiery as that which rises from a mixture of Antimony, or its Regulus, with Corrosive Sublimate.

Silver precipitated by the Acid of Sea-salt, and ready to be melted into a *Luna cornea*, being mixed with powdered Regulus of Antimony yields likewise a Butter of Antimony.

If you propose to make it by this means, you must mingle one part of the Regulus of Antimony in powder with two parts of the Precipitate; put this mixture into a glass retort of such a size that it may fill but one half thereof; set it in a furnace; apply a receiver; begin with a gentle heat, which will make a clear liquor come over; and then increase your fire by degrees. White vapours will rise and condense into a liquid Butter; and in the mean time there will be a slight ebullition in the receiver, attended with a little heat. Continue the fire till no-

thing more will come over; then let your vessels cool and unlute them.

You will find in the receiver an Oil or Butter of Antimony, partly fluid and partly congealed, somewhat inclining to yellow, weighing an eighth part more than the Regulus of Antimony made use of.

The inside of the retort will be carpeted over with small white flowers, of a brilliant silver colour, and an acid taste; and in the bottom of the retort will be found a hard, compact, ponderous mass, difficult to break, yet falling of itself to a powder; its colour externally grey, white, and blueish; internally black, and shining much like Regulus of Antimony; having a saltish taste on its surface, and weighing about a sixteenth less than the Precipitate of Silver employed in the operation.

This experiment demonstrates that the Acid of Sea-salt hath a greater affinity with Regulus of Antimony than with Silver.

The Butter of Antimony prepared by this method is somewhat less caustic than that made with Corrosive Sublimate. It is called the *Lunar Butter of Antimony*.

The effervescence that arises in the receiver is remarkable. Probably the Acid of Sea-salt, though reduced into vapours when it ascends out of the retort, is not yet perfectly combined with the reguline part of the Antimony, which it nevertheless carries over with it, and the union is completed in the receiver; which occasions the effervescence observed.

The little white silvery flowers, adhering to the inside of the retort, are flowers of Regulus of Antimony, which sublime towards the end of the distillation.

The compact mass, found at the bottom of the retort, is no other than the Silver separated from its Acid, and combined with a portion of the Regulus of Antimony. The colours and the saltish taste of its

its surface are occasioned by a remainder of the Marine Acid. This Silver is rendered brittle and eager by the union it hath contracted with some of the Regulus of Antimony.

It is easy to purify it, and restore its ductility, by separating it from the Regulus of Antimony. There are several ways of doing this: one of the most expeditious is to flux it with Nitre, which burns and converts to a calx the semi-metal with which the Silver is adulterated.

P R O C E S S XII.

Butter of Antimony decomposed by means of Water only. The Pulvis Algaroth, or Mercurius Vitæ. The Philosophic Spirit of Vitriol.

MELT with a gentle heat as much Butter of Antimony as you please. When it is melted, pour it into a large quantity of warm water. The water will immediately grow turbid, but whitish, and let fall a great quantity of white powder. When all the precipitate is settled, decant the water: pour on fresh warm water; and having thus edulcorated it by several ablutions, dry it, and you have the *Pulvis Algaroth, or Mercurius Vitæ*.

O B S E R V A T I O N S.

IN the preceding processes we observed that the Marine Acid will not dissolve the reguline part of Antimony, unless it be very highly concentrated, and more so than it can possibly be while in the form of a liquor. Of this the experiment before us is a further proof. Whilst the Marine Acid is so perfectly dephlegmated, as it is in Corrosive Sublimate and Butter of Antimony, it remains combined with the reguline part of Antimony; but if this com-

bination be dissolved in water, the moment the Acid is weakened by the interposition of the particles of water, it becomes incapable of continuing united with the semi-metal which it had before dissolved; deserts it, and lets it fall in the form of a white powder.

The *Pulvis Algaroth* is therefore no other than the reguline part of Antimony, attenuated and divided by the union it had contracted with the Acid of Sea-salt, and afterwards separated from that Acid by the intervention of water alone. The proof is, that this powder retains none of the properties of the Butter of Antimony: it is neither so fusible nor so volatile; on the contrary, it is capable of sustaining a very strong degree of fire, without subliming and without melting: it may be reduced to a Regulus: it hath not now the same caustic nature: it is only an emetic; which however is extremely violent, and on that account is never prescribed by any prudent physician.

Another proof, that the Marine Acid is separated from the Regulus of Antimony in the precipitation of the *Pulvis Algaroth*, is, that the water in which this precipitation is made becomes acid, or a sort of weak Spirit of Salt. If it be evaporated, and concentrated by distillation, a very strong acid liquor may be obtained from it. This Acid goes, very improperly, by the name of the *Philosophic Spirit of Vitriol*; for it is rather a Spirit of Salt.

The *Pulvis Algaroth*, made with Butter of Antimony procured from the Regulus, is whiter than that made with Butter of Antimony procured from crude Antimony; probably because the latter always retains some sulphureous particles.

Butter of Antimony exposed to the air attracts the moisture thereof, and partly runs into a liquor; but, as fast as this liquor is produced, it deposits a white sediment, which is an actual *Pulvis Algaroth*
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This also is very agreeable to what we advanced touching the decomposition of Butter of Antimony by the addition of water. The Butter attracts the moisture of the air, because the Acid it contains is exceedingly concentrated; and this moisture produces the same effect as water purposely added.

P R O C E S S XIII.

Bezoar Mineral. The Bezoartic Spirit of Nitre.

MELT Butter of Antimony over warm ashes, and put it into a phial or matrafs. Gradually pour on it good Spirit of Nitre, till the matter be entirely dissolved. This usually requires as much Spirit of Nitre as there is Butter of Antimony. During the dissolution fumes will rise, which must be carefully avoided. Pour your solution, which will be clear and of a redish colour, into a glass cucurbit, or a pan of stone-ware; set it in a sand-bath, and evaporate to dryness with a moderate heat. There will be left a white mass, weighing a fourth part less than the whole quantity used, both of the Butter and the Spirit of Nitre. Let it cool, and again pour on it as much Spirit of Nitre as you used the first time. Place the vessel again in the sand-bath, and evaporate the moisture as before. You will have a white mass that hath neither gained nor lost in weight. On this pour, for the third time, the same quantity of Spirit of Nitre as you did the first time. Again evaporate the moisture to perfect dryness: then increase your fire, and calcine the matter for half an hour. You will have left a dry, friable, light, white matter, of an agreeable acid taste; which will fall into a coarse powder, and must be kept in a phial carefully stoppt. This is *Bezoar Mineral*: it is neither caustic nor emetic, and has only a sudorific vir-

tue. It obtained the name it bears, because, like the animal Bezoar, it was imagined to have the property of resisting poison.

OBSERVATIONS.

It is not surprizing that the Nitrous Acid poured on Butter of Antimony should dissolve it, and unite with it: for with the Marine Acid, which makes a part of this combination, it forms an *Aqua Regis*, which we know is the true solvent of the reguline part of Antimony. But in this dissolution, and the changes it produces, there are some things very remarkable and worthy of attention. 1. The Nitrous Acid, by uniting with the Butter of Antimony, deprives it of its property of rising with a very gentle heat, and makes it much more fixed: it can now be dried, and suffer all its moisture to be evaporated; which is not to be done with pure Butter of Antimony: for that, being exposed to a certain degree of heat, instead of letting go its moisture and remaining dry, rises wholly, without the least appearance of any separation of parts.

2. The Butter of Antimony, which before its combination with the Nitrous Acid is a most violent Caustic and Corrosive, becomes so mild after it, that it may not only be taken internally without danger, but hath scarce any sensible operation.

The following considerations will lead us to a reasonable explanation of these phenomena. 1. The Nitrous Acid, when combined with metallic substances, doth not communicate to them the same volatility as they acquire from the Marine Acid. Hence it follows that, if the Nitrous Acid be added to any combination of a metallic substance with the Marine Acid, this new compound will be rendered less volatile, and consequently more able, without rising in vapours, to bear a degree of heat sufficient to carry off part of its Acid. This is the case

case with Butter of Antimony, after Spirit of Nitre is mixed with it: especially considering, 2. That the Nitrous Acid cannot unite with the reguline part of the Butter of Antimony without weakening the connection between it and the Marine Acid; whence it follows that the combination of the Nitrous Acid further facilitates the separation of the Marine Acid from the Regulus. Now as soon as the Marine Acid quits the reguline part, that part becomes more fixed, and consequently more capable of enduring the degree of heat requisite to discharge all the adhering Acid; and not only the Marine, but even the Nitrous also. It is not therefore surprizing that, after the Antimony which remains combined with the Nitrous Acid is dried, it should not possess that corrosive power which it derives only from the Acids wherewith it is armed. In order to free it more perfectly from all Acid, we order the fire to be increased after the third desiccation; and the remainder of the Butter of Antimony to be calcined for a full half-hour longer.

That the Marine Acid is separated from the reguline part of the Butter of Antimony, by the desiccations it undergoes in converting it into Bezoar, is proved by this, that, when these desiccations are performed in close vessels, the liquor drawn off is a true *Aqua Regis*, known by the name of the *Bezoartic Spirit of Nitre*.

It remains to be considered why the Bezoar mineral, though freed from all Acid, is not emetic; while the *Pulvis Algaroth*, which is likewise the reguline part of the Butter of Antimony deprived of its Acid, is such a violent emetic, and even to be dreaded for its remaining causticity.

In order to discover the reason of this difference, it is proper to observe that, when we say Bezoar mineral and the *Pulvis Algaroth* contain no Acid, we must not be understood in too strict a sense: on the contrary,

contrary, there is reason to think that a certain quantity of Acid still remains in each of them; which however is scarce worth notice, in comparison of the quantity each contained at first. This being allowed, it will not be hard to find the difference between these two preparations of Antimony. The *Pulvis Algaroth* is deprived of its Acid by the addition of water alone, which only carries off all the loose Acid it can take up, without making any change in the nature of that which continues in combination with the reguline part. Now, as the Marine Acid is not intimately united with the reguline part in Butter of Antimony; as it still retains some of its properties, such as attracting the moisture of the air, giving manifest tokens of its Acid nature, &c; and as the corrosive quality of this compound depends on this last in particular; the small portion of Acid left in the *Pulvis Algaroth* will in some degree preserve its former character: and hence comes the effect of this powder, which still retains a little of the corrosive quality that belonged to the Butter of Antimony.

But this is not the case with the small remainder of Acid, which possibly still continues united with the Bezoar mineral prepared as here directed. This compound hath been exposed to a fire sufficient, not only to dry it, but even to calcine it. Now fire is capable of producing great changes in the texture of bodies. It must have forced off from the Bezoar all the Acid that was not intimately combined with it; and that part which it could not drive off, because of its obstinate adhesion, it must have further united and combined more closely with the metallic earth: for we see that fire greatly promotes the action of solvents on the matters with which they are united.

With regard to the properly emetic quality of the *Pulvis Algaroth*, it cannot be imputed to the combination of any Acid with that powder; since

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we see that the most powerful emetic preparations of Antimony, viz. its Regulus and Glafs, contain no Acid: it must therefore be attributed to some cause different from that on which its corrosive quality depends. This cause we shall easily find by attending to the different manners in which the Marine Acid, when alone and in *Aqua Regia*, operates on the reguline part of Antimony.

The Marine Acid alone dissolves the Regulus of Antimony, but with great difficulty; nor doth it effect a complete dissolution thereof, as is evident from what hath been already said: whereas the Marine Acid, combined with the Nitrous Acid, and therewith forming an *Aqua Regis*, as in the preparation of Bezoar, dissolves the reguline part of Antimony completely and radically. Now, it is certain that, the more efficaciously Acids operate on metallic substances, the more of their phlogiston do they destroy; and we cannot but recollect that the preparations of Antimony are so much the less emetic the less phlogiston they contain, or the further they recede from the nature of a Regulus, and the nearer they approach to that of Diaphoretic Antimony: consequently it is plain how Bezoar mineral, which is a sort of calx of Antimony entirely deprived of its phlogiston by the intimate dissolution thereof made by the Acids of the *Aqua Regis*, may be in no degree emetic; while the *Pulvis Algaroth*, being a true Regulus of Antimony, on which the Marine Acid hath operated but very superficially, and which still contains a great deal of phlogiston, is a most violent emetic.

PROCESS XIV.

Flowers of Antimony.

TAKE an unglazed earthen pot, having an aperture in its side, with a stopple to shut it close. Set this pot in a furnace, the cavity whereof it may fit as exactly as possible; and fill up with lute the space, if any, left between the vessel and the furnace. Over this vessel fix three aludels, with a blind-head at the top; and light a fire in the furnace under the pot.

When the bottom of the pot is thoroughly red, throw into the lateral aperture a small spoonful of powdered Antimony. Stir the matter immediately with an iron spatula made a little bending, in order to spread it over the bottom of the vessel, and then stop the hole. The flowers will rise and adhere to the insides of the aludels. Keep up the fire so that the bottom of the pot may always continue red; and, when nothing more sublimes, put in a like quantity of Antimony, and operate as before. In this manner go on subliming your Antimony, till you have as many flowers as you want. Then let the fire go out; and when the vessels are cold unlute them. You will find flowers adhering all round the insides of the aludels and the head, which you may collect with a feather.

OBSERVATIONS.

ANTIMONY is a volatile mineral, capable of being sublimed into flowers; but this cannot be effected without occasioning a notable change in its parts. The reguline and the sulphureous parts are not united so intimately, or in the same proportion, in the flowers as in the Antimony itself; and accordingly we find these flowers have a strong emetic quality, which Antimony hath not. They are of divers colours;

colours; which probably arises from their containing more or less Sulphur. Three or four aludels are placed one over another, not only with a view to provide a greater surface to which the flowers may adhere, but also to give them room enough to circulate, without which they might burst the vessel.

If you introduce the nose of a pair of bellows into the pot that contains the Antimony, and blow upon it, the sublimation of the flowers will be much sooner effected. This is a general rule with regard to all matters that are to be sublimed or evaporated; the reason of which we have already given.

It is proper that no interval be left between the furnace and the pot containing the Antimony, lest the heat should be thereby communicated to the aludels, on which the flowers fasten best when they are cold.

After the operation there remains, at the bottom of the pot, a portion of Antimony half calcined; which being pulverized, and thoroughly calcined till it emit no fume, may be employed to make the Glass of Antimony.

P R O C E S S X V.

Regulus of Antimony converted into Flowers.

PULVERIZE your Regulus of Antimony: put the powder into an unglazed earthen pot: three or four fingers breadth above the powder, fit into the pot a little cover, made of the same earth, and having a small hole in its middle, so that it may with ease be placed in the pot, and taken out when there is occasion: cover the mouth of the pot with a common lid; set it in a furnace, and kindle a fire under it sufficient to make the bottom of the pot red, and to melt the Regulus. When it hath been thus kept

kept in fusion for about an hour, let the fire go out, and the whole cool. Then remove the two covers. You will find adhering to the surface of the Regulus, which will be in a mass at the bottom of the pot, white flowers resembling snow, intermixed with beautiful, brilliant, silver-coloured needles. Take them out, and you will find them make about one part in sixty-two of the whole Regulus employed.

Put the covers again in their places, and proceed in the same manner as before : when the vessels are cold you will find half as many more flowers as you got the first time.

Proceed thus till you have converted all your Regulus into flowers. This will require a considerable number of sublimations, which, as you advance, will always yield you a greater portion of flowers ; respect, however, being had to the quantity of Regulus remaining in the pot.

OBSERVATIONS.

WE must here repeat what we said just before, in our observations on the preceding process, viz. that Regulus of Antimony is capable of being wholly elevated and sublimed by the action of fire ; but that it must at the same time undergo a considerable change and alteration. These flowers of Regulus of Antimony are very different from every other antimonial preparation. They resemble the Pearly Matter in this, that they cannot be reduced to a Regulus by any means whatever : but they differ from it, 1. in that they are not fixed ; for, when melted by fire, they fly wholly away in vapours : 2. in that they are capable of being dissolved by *Aqua Regis*, much in the same manner as the Regulus ; whereas the Pearly Matter is known to be indissoluble by any Acid.

As soon as Regulus of Antimony is in fusion, it begins to sublime into flowers ; so that it is needless

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to apply a greater degree of heat than is just sufficient to melt it.

A pan of some width is preferable to a crucible for this operation; because the upper surface of the Regulus melted therein is larger; and, the larger that surface is, the more considerable is the quantity sublimed from it.

The two covers which are applied within and over the pot are designed to check, as much as possible, the dissipation of the melted Regulus; yet without absolutely excluding the free access of the air, the concurrence of which is useful in all metallic sublimations. Notwithstanding these precautions, it is impossible to prevent the escape of some of the Regulus, in vapours that cannot be confined. Somewhat less than three fourths of the Regulus made use of is nearly the yield in flowers: the rest evaporates through the interstices left by the covers, which must not be luted for the reason just assigned.

C H A P. II.

Of B I S M U T H.

P R O C E S S I.

To extract Bismuth from its Ore.

BREAK the ore of Bismuth into small pieces, and therewith fill a crucible either of earth or iron. Set the crucible in a furnace, and light such a fire that the bits of ore may become moderately red. Stir the ore from time to time, and, if you perceive it crackle and fly, keep the crucible covered. At the bottom you will find a button of Bismuth.

OBSERVATIONS.

THE extraction of Bismuth from its ore requires nothing but simple fusion, without the addition of any inflammable matter, because it is naturally possessed of its metalline form. Nor does it require any flux; because it is very fusible: which allows us to melt it, and collect it in a mass, without the necessity of fusing likewise the earthy and stony matters in which it is lodged. These matters remain in their first state; and the melted Bismuth descends by its gravity to the bottom of the crucible. No greater degree of heat must be applied, on this occasion, than is necessary to melt the semi-metal: for, as it is volatile, part of it would be dissipated; so that much less thereof would be obtained, if the fire were made too strong, and so much the less as another portion thereof would be converted into a calx. For the same reason, the crucible must be taken out of the furnace as soon as you perceive that all the Bismuth contained in the ore is melted, and that the button doth not increase.

The ore of Bismuth may also be treated like the ores of Lead and Tin; that is, it may be reduced into a fine powder, mixed with the black flux, a little Borax, and Sea-salt; put into a close crucible, and fused in a melting furnace. In that case you will find a button of Regulus covered with scoria. By this method rather more Bismuth is obtained; and it is best to make use of it when the ore is poor, because, in such a case, none at all would be obtained by the other process. But here care must be taken to apply at once the degree of fire necessary to melt the mixture: for, if it remain long in the fire, much Bismuth will be lost, on account of the great volatility of this semi-metal, and the facility with which it turns to a calx.

Bismuth

Bismuth is pretty frequently found pure in its earthy and stoney matrices; and when mineralized it is usually so by Arsenic, which, being still more volatile, flies off in vapours while the ore is melting, provided it be but in a small quantity: if there be much of it, and the ore be smelted by fusing it with the black flux, the Arsenic also is reduced to a Regulus, unites more intimately with the Bismuth, becomes a little more fixed by that union, and increases the quantity of the semi-metallic mass found after the fusion.

Though Bismuth be not usually mineralized by Sulphur, that is not because it is incapable of uniting therewith; for, if equal parts of Bismuth and Sulphur be melted together, after the fusion the Bismuth will be found increased near an eighth part, and formed into a mass disposed in needles much like Antimony.

When we come to treat of the ore of Arsenic, we shall have occasion to say a good deal more concerning Bismuth and its ore, because these minerals resemble each other very much.

Mr. Geoffroy, son of the Academician, hath shewn in a Memoir read before the Academy of Sciences, that there is a great resemblance between Bismuth and Lead. That Memoir, which contains only the beginning of Mr. Geoffroy's course of experiments, proves that the Author supports with dignity the glory of his name. It is there demonstrated, by a very great number of experiments, that fire produces the same effects on Bismuth as on Lead. This semi-metal is converted into a calx, into litharge, and into glass, as Lead is; and these productions have the same properties as the preparations of Lead made with the same degree of fire. Bismuth is capable of vitrifying all the imperfect metals, and of carrying them off through the pores of the crucible. So that Gold and Silver may be

purified and cupelled by its means, as well as with Lead. You may on this occasion turn to what we have said concerning Lead.

PROCESS II.

Bismuth dissolved by Acids. Magistery of Bismuth. Sympathetic Ink.

INTO a matrafs put Bismuth broken into little bits: pour on it, by little and little, twice as much *Aqua Fortis*. This Acid will attack the semi-metal briskly, and dissolve it entirely, with heat, effervescence, vapours, and puffing up. The solution will be clear and limpid.

OBSERVATIONS.

OF all Acids the Nitrous is that which best dissolves Bismuth. It is not necessary, on this occasion, to place the phial, in which the dissolution is performed, on a sand-heat, as in most other metallic dissolutions: on the contrary, care must be taken not to pour on all the *Aqua Fortis* at once; because it operates with so much activity that the mixture will heave up and run over the vessel.

The bare addition of water is sufficient to precipitate the solution of Bismuth. If this solution be mixed with a very large proportion of water, the liquor grows turbid, appears milky, and deposits a precipitate of a very beautiful white. This is that White which the Ladies use at their toilets.

Water produces this precipitation by weakening the Acid; which probably is incapable of keeping the Bismuth dissolved, unless it have a certain degree of strength.

If you would have a Magistery of Bismuth beautifully white, you must perform the dissolution with an *Aqua Fortis* that is not tainted with any mixture
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of the Vitriolic Acid; for this gives the precipitate a dirty white colour, inclining to grey. Several authors advise the use of a solution of Sea-salt, instead of pure water, for precipitating the Bismuth, imagining that this Salt will effect a precipitation here as it does in the cases of Silver and Lead. But Mr. Pott, a German Chymist, who hath published a long dissertation on Bismuth, pretends, on the contrary, that neither Sea-salt, nor its Acid, is capable of precipitating this semi-metal; and that when a precipitation takes place on mixing them with our solution, it is brought about only by means of the water in which those substances are diffused.

Bismuth may also be precipitated by the means of Fixed or Volatile Alkalis; but the precipitate is not of so fine a white as when procured by the means of pure water only.

If a greater quantity of *Aqua Fortis*, than that prescribed in the process, be made use of to dissolve the Bismuth, a great deal more water will also be required to precipitate the Magistery; because there will be much more Acid to weaken. This White ought to be well washed, in order to free it from any remainder of acidity; and it should be kept in a bottle well stopped, because the access of the air makes it turn brown, and if any of the Acid be left it will turn it yellow.

A solution of Bismuth prepared with the proper quantity of *Aqua Fortis*, that is, with two parts of the Acid to one of the semi-metal, concretes into little crystals almost as soon as made.

Aqua Fortis not only acts on Bismuth when separated from its ore, and reduced to a Regulus, but attacks it even in its ore, and likewise dissolves at the same time some portion of the ore itself. With this solution of the ore of Bismuth Mr. Hellot makes a very curious Sympathetic Ink, differing from all that were known before.

Mr. Hellot prepares the liquor in the following manner: " He bruises the ore of Bismuth to a
" coarse powder. On two ounces of this powder
" he pours a mixture of five ounces of common
" water with five ounces of *Aqua Fortis*. He does
" not heat the vessel till the first ebullitions are
" over. He then sets it in a gentle sand-heat, and
" lets it digest there till he sees no more air-bubbles
" rise. When none appear in this heat, he increases
" it so as to make the solvent boil slightly for a
" full quarter of an hour. It takes up a tincture
" nearly of the colour of brown beer. The ore
" that gives the *Aqua Fortis* this colour is the best.
" He then lets the solution cool, laying the matrafs
" on its side, that he may decant the liquor more
" conveniently when all is precipitated that is not
" taken up by the solvent.

" The second vessel, into which the liquor is first
" decanted, he also lays declining, that a new pre-
" cipitation of the undissolved matters may be ob-
" tained; after which he pours the liquor into a
" third vessel. This liquor must not be filtered, if
" you would have the rest of the process succeed
" perfectly; because the *Aqua Fortis* would dissolve
" some of the paper, and that would spoil the co-
" lour of your liquor.

" When this solution, which Mr. Hellot calls the
" *Impregnation*, is thoroughly clarified by being
" decanted three or four times, he puts it into a
" glass basin with two ounces of very pure Sea-
" salt. The fine white salt made by the sun suc-
" ceeded best with Mr. Hellot. If that cannot be
" had, common bay-salt, purified by solution, fil-
" tration, and crystallization, may be used instead
" of it. But as it is rare to meet with any of the
" sort that is not a little tainted with iron, the
" white bay-salt is to be preferred. The glass
" basin he sets in a gentle sand-heat, and keeps it
" there

“ there till the mixture be reduced by evaporation
 “ to an almost dry saline mass.

“ If you desire to save the *Aqua Regis*, the Im-
 “ pregnation must be put into a retort, and distilled
 “ with the gentle heat of a sand-bath. But there
 “ is an inconvenience, as Mr. Hellot observes, in
 “ employing a retort; which is, that, as the saline
 “ mass cannot be stirred while it coagulates in the
 “ retort, it is reduced to a compact cake of co-
 “ loured Salt, which presents but one single sur-
 “ face to the water in which it must be dissolved;
 “ so that the dissolution thereof takes up some-
 “ times no less than five or six days. In the ba-
 “ son, on the contrary, the saline mass is easily
 “ brought to a granulated Salt, by stirring it with
 “ a glass rod; and, when thus granulated, it has
 “ a great deal more surface; it dissolves more ea-
 “ sily, and yields its tincture to water in four
 “ hours time. Indeed one is more exposed to the
 “ vapours of the solvent, which would be dan-
 “ gerous, if the operation were to be often per-
 “ formed, without proper precautions.

“ When the basin, or little vessel, containing the
 “ mixture of the Impregnation and Sea-salt is heat-
 “ ed, the liquor, which was of an orange-coloured
 “ red, becomes a crimson red; and, when all the
 “ phlegm of the solvent is evaporated, it acquires
 “ a beautiful emerald colour. By degrees it
 “ thickens, and acquires the colour of a mass of
 “ Verdegris. It must then be carefully stirred with
 “ the glass rod, in order to granulate the Salt,
 “ which must not be kept over the fire till it be
 “ perfectly dry; because you run a risk of losing
 “ irrecoverably the colour you are seeking. You
 “ may be sure you have lost it, if by too much
 “ heat the Salt that was of a green colour become
 “ of a dirty yellow. If it be once brought to this
 “ state, it will continue without changing when

“ cold : but if care be taken to remove it from the
“ fire while it is still green, you will see it gradu-
“ ally grow pale, and become of a beautiful rose
“ colour as it cools.

“ Mr. Hellot removes it from this vessel, and
“ throws it into another containing distilled rain-
“ water : and this second vessel he keeps in gentle
“ digestion till he observes that the powder which
“ falls to the bottom is perfectly white. If, after
“ three or four hours digesting, this powder still
“ continues tinged with a rose colour, it is a proof
“ that water enough was not added to dissolve all
“ the Salt impregnated with the tincture of the so-
“ lution. In this case, the first tinged liquor must
“ be poured off, and fresh water added, in propor-
“ tion to the quantity of tinged Salt, that is sup-
“ posed to remain mixed with the precipitate.

“ When the ore is pure, and doth not contain a
“ great deal of fusible stone, commonly called
“ *Fluor* or *Quartz*, an ounce of it generally yields
“ tincture enough for eight or nine ounces of wa-
“ ter, and the liquor is of a beautiful colour, like
“ that of the lilach or pipe-tree blossom. In order
“ to prove the effect of this tincture, you must
“ write with this lilach-coloured liquor on good
“ well-gummed paper, that does not sink : or you
“ may use it to shade the leaves of some tree or
“ plant, having first drawn the outlines thereof
“ lightly, with China-ink or with a black-lead
“ pencil. Let this coloured drawing, or writing,
“ dry in a warm air. You will perceive no colour
“ while it is cold ; but, if it be gently warmed
“ before the fire, you will see the writing, or the
“ drawing, gradually acquire a blue or greenish-
“ blue colour, which is visible as long as the paper
“ continues a little warm, and disappears entirely
“ when it cools.”

The singularity of this sympathetic ink consists
in its property of disappearing entirely and becom-
ing

ing invisible, though it be not touched with any thing whatever: and this distinguishes it from all others; which, when once rendered visible by the application of proper means, do not again disappear, or at least not without touching the strokes on the paper with some other liquor.

Mr. Hellot made a vast variety of experiments on this subject, and gave his sympathetic ink successively the properties of all others that are known.

It follows from Mr. Hellot's experiments that it is the Acid of Sea-salt which makes this saline *magma* of a green colour while it is hot; that without this Acid the saline matter continues red; and that the solution of Bismuth-ore in *Aqua Fortis* may therefore serve as a touchstone, to discover whether or no any unknown Salt under examination contains Sea-salt, or a portion of the Marine Acid.

He also proves, in the Memoirs he hath given in on this subject, that the Nitrous Acid is the true solvent of those ores of Bismuth which contain moreover Smalt and Arsenic. That Acid dissolves all the metallic and colouring matters contained in those ores, sparing nothing but the sulphureous and arsenical portion, the greatest part of which remains precipitated; and from this colouring matter the sympathetic ink derives its virtue.

Under the head of Arsenic we shall speak more amply of this matter in Cobalt, or the ore of Arsenic, that gives a blue colour to the sand with which it is vitrified.

The Vitriolic Acid doth not, properly speaking, dissolve Bismuth. If to one part and an half of this semi-metal you add one part of Oil of Vitriol; distill the whole to dryness; and then lixivate with water what remains in the retort; the liquor you obtain by this means will be of a redish yellow colour, but will let nothing fall when mixed with an Alkali: and this shews that the Vitriolic

Acid acts only upon the inflammable part of Bismuth, and doth not dissolve its metallic earth.

It dissolves the ore of Bismuth more perceptibly than Bismuth itself; because the ore contains, besides the reguline part, an arsenical matter, and a coloured matter, over which perhaps it hath more power.

The Acid of Sea-salt attacks and dissolves Bismuth in some small measure, but slowly and with difficulty. That this Acid dissolves a portion of our semi-metal may be proved, by mixing a Fixed or Volatile Alkali with Spirit of Salt in which Bismuth hath lain some time digesting; for then a precipitate falls.

But, though the Marine Acid be capable of dissolving Bismuth, it doth not follow that it hath a greater affinity than the Nitrous Acid with this metallic substance, as some Chymists have thought; who imagined that, in the precipitation of the Magistery of Bismuth by a solution of Sea-salt, the Acid of that Salt quits its basis to unite with the Bismuth which it precipitates, as is the case in the precipitations of Lead and of Silver by the same Salt, and that it forms, on this occasion, a *Bismuthum corneum*.

On this subject Mr. Pott observed, 1. that, when only a small quantity of the solution of Sea-salt is mixed with the solution of Bismuth in the Nitrous Acid, no precipitate is formed: now it is certain that when the smallest quantity whatever of Sea-salt is mixed with the solution either of Lead or of Silver, a precipitate is immediately deposited, in a quantity proportioned to that of the Salt used.

2. Mr. Pott, having examined the precipitate of Bismuth thrown down by a solution of Sea-salt, found it not to have the properties of a metallic substance rendered horny: on the contrary, that precipitate being exposed to a very violent fire appeared refractory, and could not be melted.

C H A P,

C H A P. III.

Of Z I N C.

P R O C E S S I.

To extract Zinc from its Ore, or Calamine.

TAKE eight parts of Calamine reduced to a powder; mix this powder accurately with one part of fine charcoal-dust, previously calcined in a crucible to free it from all moisture: put this mixture into a stone retort coated with lute, leaving a third part of it empty: set your retort in a reverberatory furnace, capable of giving a very fierce heat. To the retort apply a receiver, with a little water in it. Kindle the fire, and raise it by degrees till the heat be strong enough to melt copper. With this degree of fire the Zinc being metallized will separate from the mixture, and sublime into the neck of the retort, in the form of metallic drops. Break the retort when it is cold, and collect the Zinc.

O B S E R V A T I O N S.

THE process here given for smelting Zinc out of Calamine is taken from the Memoirs of the Academy of Sciences at Berlin. The author of it is Mr. Marggraff, a skilful Chymist, whom we have already had occasion to mention under the article of Phosphorus.

Till this process was published, we knew no method of obtaining pure Zinc directly from the *Lapis Calaminaris*.

Most

Most of the Zinc we have comes from an ore of difficult fusion that is worked at Goslar, and yields, at one and the same time, Lead, Zinc, and another metallic matter called *Cadmia Fornacum*, which also contains much Zinc, as we shall afterwards see.

The furnace used for smelting this ore is closed on its fore-side with thin plates or tables of stone, not above an inch thick. This stone is greyish, and bears a violent fire.

In this furnace the ore is melted amidst charcoal, by the help of bellows. Each melting takes twelve hours, during which time the Zinc flowing with the Lead is resolved into flowers and vapours, great part of which adheres to the sides of the furnace in the form of a very hard crust of earth. The workmen take care to remove this crust from time to time ; for it would otherwise grow so thick at last as to lessen the cavity of the furnace very considerably.

There adheres moreover to the fore-part of the furnace, which is formed, as we said before, of thin plates of stone, a metallic matter, which is the Zinc, and is carefully collected at the end of each melting, by removing from this part all the live coals. A quantity of small-coal is laid unlighted at the bottom ; and on this small-coal, by striking the stone plates gently with a hammer, the Zinc is made to fall out of the other matter, known by the Latin name of *Cadmia Fornacum*, among which it appears fixed in a radiated form. To this other matter we may properly enough give the name of *Furnace-Calamine*. The Zinc falls in the form of a melted metal, all on fire, and in a bright flame. It would soon be entirely burnt and reduced to flowers, as we shall see, if it were not extinguished, and easily cooled and fixed, by being hid under the unlighted small-coal placed below on purpose to receive it.

The

The Zinc adheres to the fore-part of the furnace preferably to any other, because that being the thinnest is therefore the coolest: and, in order further to promote its fixing on this part, they take care to keep the thin stone plates cool during the operation, by throwing water on them.

Hence it appears that Zinc is not extracted from its ore by fusion and the precipitation of a Regulus, like other metallic substances. This is owing to the great volatility of our semi-metal, which cannot, without subliming, bear the degree of fire necessary to melt its ore. It is at the same time so combustible, that a great part of it rises in flowers which have not the metalline form.

Mr. Marggraff provides against these inconveniences by working the ore of Zinc in close vessels. By this means he prevents the Zinc from taking fire, and being converted into flowers; so that it sublimes in its metalline form. The water in the recipient serves to receive and cool the drops of Zinc that may be forced quite over the helm. As the operation requires a most violent fire, these drops must needs issue exceeding hot, and, without this precaution, break the recipient.

Mr. Marggraff by the same process extracted Zinc out of the Furnace-Calamine procured from ores containing Zinc; from Tutty, which is a sort of furnace-calamine; from the flowers and from the calx of Zinc; and from the precipitate of White Vitriol: all of them matters known to be Zinc, that wanted nothing but the phlogiston to give it a semi-metalline form, and from which nevertheless nobody could ever before him procure any Zinc.

Mr. Marggraff observes, that the Zinc obtained by his process bears being flatted under the hammer into pretty thin plates; which the common Zinc will not do. The cause of this probably is,
that

that the Zinc obtained by his method is more intimately combined with the phlogiston, and contains a greater quantity thereof, than that which is procured in the ordinary way.

P R O C E S S . II.

To sublime Zinc into Flowers.

TAKE a very deep, large crucible: place it in a furnace, so that it may stand inclining in an angle of forty-five degrees nearly. Throw some Zinc into it, and kindle a fire in the furnace somewhat stronger than would be necessary to keep Lead in fusion. The Zinc will melt. Stir it with an iron wire, and there will appear on its surface a very bright white flame: two inches above this flame a thick smoke will be formed, and with this smoke exceeding white Flowers will rise, and remain some time adhering to the sides of the crucible, in the form of a very fine light down. When the flame slackens, stir your melted matter again with the iron wire: you will see the flame renewed, and the Flowers begin again to appear in greater abundance. Go on thus till you observe that the matter will not flame, nor any more flowers rise.

O B S E R V A T I O N S.

ZINC takes fire very easily as soon as it is affected by a certain degree of heat; which proves that in the composition of this semi-metal there is very much phlogiston, united but slightly with its metallic earth. The Flowers into which Zinc resolves, during its combustion, are of a perfectly singular nature, and differ greatly from all the other productions obtainable out of metallic substances.

They

They may be considered as the very calx of Zinc, or its metallic earth robbed of its phlogiston, and sublimed during the combustion of this semi-metal, being probably carried up by the phlogiston in flying off. For these Flowers, when once sublimed, are afterwards exceedingly fixed: they sustain the greatest violence of fire without rising, and are converted by it into a sort of glass.

None of the methods hitherto employed, for restoring to the Flowers of Zinc their metalline form, have ever succeeded. When treated like other metalline calxes in a crucible, with every kind of inflammable matter, and different sorts of reducing fluxes, they never can be re-metallized: they only melt with the flux, and produce a kind of Glass.

Mr. Marggraff indeed, as mentioned before, obtained Zinc from these Flowers, by treating them as he did Calamine in a retort with charcoal-dust: but as the Flowers often carry up with them little particles of undecomposed Zinc, there still remains some doubt concerning the reduction of these Flowers, even by this method.

If the crucible, into which you put the Zinc to be converted into Flowers, instead of being left open, as directed, be covered with another crucible inverted, the two vessels luted together, placed in a melting furnace, and a strong fire immediately kindled and kept up for about half an hour; you will find, when the vessels are cold, that all the Zinc hath left the lower crucible, and is sublimed into the upper one, in its metalline form, without suffering any decomposition. This experiment proves that Zinc, to be converted into Flowers, must necessarily be set on fire and burnt. As it cannot burn in close vessels, any more than other combustible bodies, and as it is volatile, it sublimes without suffering any decomposition. Regulus of Antimony and Bismuth may be sublimed in the same manner;

but not so easily as Zinc, which is still more volatile than those other semi-metals.

It is necessary to stir the Zinc in fusion from time to time with an iron wire, when you intend to convert it into Flowers: for there forms on its surface a grey crust that obstructs its deflagration, and beneath which it is gradually converted into a clotted calx. In order, therefore, to promote the rising of the Flowers, care must be taken to break this crust, as oft as it begins to form. On this there immediately appears a very bright white flame: two inches above the flame is seen a thick smoke, and with this smoke very white Flowers rise, that continue some time adhering to the inside of the crucible, in the form of a fine down.

M. Malouin, who, in fundry Memoirs on Zinc, hath endeavoured to discover what resemblance there is between this semi-metal and Tin, tried to calcine Zinc in the same manner as Tin; but found it somewhat more difficult. Zinc, while it is not in fusion, doth not calcine; but it begins to turn to a calx the moment it begins to melt. M. Malouin, having repeated the fusion of Zinc a great number of times, by that means collected at last a quantity of the calx of this semi-metal, resembling other metalline calxes. This calx of Zinc he melted in a crucible with animal fat; whereby the calx was remetallized, and reduced to Zinc. There is great reason to believe that the calx of Zinc made by this method is not so much burnt as the Flowers, and that it still contains a portion of phlogiston.

P R O C E S S I I I .

To combine Zinc with Copper. Brass. Prince's Metal, &c.

POUND one part and an half of Calamine, and an equal quantity of charcoal: mingle these two powders together, and moisten them with a little water. Put this mixture into a large crucible, or some other earthen vessel that will bear a melting heat. Amongst and over this mixture put one part of very pure Copper in thin plates, and then put fresh charcoal-dust over all: cover the crucible; set it in a melting furnace; put coals all round it, and let them kindle gradually. Raise the fire so as to make the crucible very red-hot. When you observe that the flame hath acquired a purple or blueish-green colour, uncover the crucible, and dip into it an iron wire, to examine whether or no the copper be in fusion under the charcoal-dust. If you find it is, moderate the force of the fire a little, and let your crucible remain in the furnace for a few minutes. Then take it out and let it cool: you will find your Copper of a gold colour, increased in weight a fourth, or perhaps a third part, and yet very malleable.

O B S E R V A T I O N S .

THE *Lapis Calaminaris* is not the only substance with which Copper may be converted into Brass: all other ores containing Zinc, the Furnace-Calamine that sublimes where such ores are worked, Tutty, Zinc in substance, may be substituted for it, and, like it, will make very fine Brass; but, in order to succeed, sundry precautions are necessary, which we shall now lay before you.

This process is a sort of cementation: for the Calamine doth not melt; only the Zinc is converted
into

into vapours, and then combines with the Copper. On this the success of the operation partly depends, as it is the means of the Copper's preserving its purity and malleability; because the other metallic substances that may be united with the ore of Zinc, or with the Zinc itself, not having the same volatility, cannot be reduced to vapours. If you are apprised that the Calamine, or other ore of Zinc used on this occasion, is contaminated with a mixture of any other metallic matter, you must mingle luting earth with the charcoal-dust and the matter containing the Zinc; make it into stiff paste with water; of this make a bed at the bottom of your crucible, and ram it hard down; lay the Copper plates thereon, cover them with charcoal-dust, and then proceed as before. By this means when the Copper melts it cannot fall to the bottom of the crucible, nor mix with the ore; but is borne up by the mixture, and cannot combine with any thing but the Zinc, that rises in vapours, and, passing through the lute, fixes in the copper.

Lapis Calaminaris, or other ore of Zinc, may also be purified before it be used for making Brasses; especially if adulterated with Lead ore, which is often the case. For this purpose the ore must be roasted in a fire strong enough to give a small degree of fusion to the leaden matter; which will thereby be reduced into larger, heavier, and tougher masses. The most subtile particles are dissipated in the torrefaction, together with some of the Calamine. The Calamine, on the contrary, is by roasting made more tender, lighter, and much more friable. When it is in this condition, put it into a washing tray or van; dip the tray in a vessel full of water, and bruise the matter it contains. The water will carry off the lightest powder, which is the Calamine, and leave nothing at the bottom of the tray but the heaviest substance; that is, the leaden matter, which

is to be rejected as useless. The powder of the Calamine will settle at the bottom of the vessel, where, after pouring off the water, it may be found, and used as above directed.

In this operation the charcoal-dust serves to prevent both the Copper and the Zinc from being calcined: and for this reason, when you work on a great quantity of materials at once, it is not necessary to use so much charcoal-dust, in proportion, as when you work but on a small quantity; because, the greater the mass of metal, the less easily will it calcine.

Though the Copper melts in this operation, yet it is far from being necessary to apply such a strong fire as Copper usually requires to melt it: for the accession of the Zinc, on this occasion, communicates to it a great degree of fusibility. The increase of its weight is also owing to the quantity of Zinc combined with it. Copper acquires still another advantage by its association with this semi-metal; for it remains longer in the fire without calcining.

Brass well prepared ought to be malleable when cold. But in whatever manner it be made, and whatever proportion of Zinc there be in it, it is constantly found quite unmalleable when red-hot.

Brass melted in a crucible, with a fierce heat, takes fire almost like Zinc, and from its surface many white flowers ascend, dancing about in flakes like the flowers of Zinc. They are indeed the flowers of Zinc, and the flame of Brass urged by a strong fire is no other than the flame of the Zinc that is united with the Copper, and at that time burns. If Brass be thus kept long in fusion it will lose almost all the Zinc it contains. It will also lose much of its weight, and its colour will be nearly that of Copper. It is therefore necessary, towards performing this operation aright, to seize the moment when the Copper is sufficiently impregnated with

Zinc, when it hath acquired the most weight and the finest colour, with the least detriment to its ductility, that is possible, and that instant to put out the fire; because, if the Copper be left longer in fusion, it will only lose the Zinc already united with it. Skill acquired by much practice, and an acquaintance with the particular Calamine employed, are necessary to guide the Artist surely through this operation; for there are very considerable differences between the fundry ores of Zinc. Some of them contain Lead, as was said above, and in others there is Iron. When these heterogeneous metals come to be mixed with the Copper, they do indeed augment its weight, but they render it at the same time pale, and make it very harsh. Some Calamines require to be roasted before they can be used for this purpose, and in the torrefaction emit vapours of a Volatile Alkali, succeeded by vapours of a Sulphureous Spirit: others exhale no vapours while roasting, and may be employed without any antecedent preparation. These different qualities must evidently produce great differences in the operation.

Brass may also be made, as Prince's metal and other imitations of Gold are actually made, by using Zinc in substance, instead of the ores that contain it. But these compositions have not, when cold, the ductility of Brass prepared with *Lapis Calaminaris*, because Zinc is seldom pure, or free from a mixture of Lead. Perhaps also the different manner in which the Zinc unites with the Copper may contribute to this variation.

To obviate this inconvenience, the Zinc must be refined from all alloy of Lead. The property of being indissoluble by Sulphur, which this semi-metal possesses, points out a very practicable method of doing it. The Zinc must be melted in a crucible and stirred briskly with a strong iron wire, while tallow and mineral Sulphur are alternately projected
upon

upon it; but so that the quantity of Sulphur may greatly exceed that of the tallow. If the Sulphur do not burn entirely away, but form a kind of scoria on the surface of the Zinc, it is a sign that your semi-metal contains Lead. In this case you must continue throwing in more Sulphur, and keep stirring the Zinc incessantly, till you perceive that the Sulphur ceases to unite any more with a metallic substance, but burns freely on the surface of the Zinc. The semi-metal is then refined; because the Sulphur, which cannot dissolve it, unites very readily with the Lead, or other metallic substance, contained in it.

If Zinc thus refined be mixed with pure Copper, in the proportion of a fourth or a third part, and the mixture be kept in fusion and constantly stirring for some time, the Brass produced will be as ductile, when cold, as that made by cementation with the *Lapis Calaminaris*.

With regard to Prince's metal, and other imitations of Gold, they are made either with Copper or Brass re-combined with more Zinc. As it is necessary, for giving them a fine golden colour, to mix with them other proportions of Zinc than that required to make Brass only, they are generally much less ductile. In 1725, M. Geoffroy gave a Memoir on this subject, in which he examined the effects of incorporating both Copper and Brass with Zinc, from a small to a very large quantity.

P R O C E S S IV.

Zinc dissolved in the Mineral Acids.

WE A K E N concentrated Oil of Vitriol by mixing with it an equal quantity of water. Into a matrals put the Zinc you intend to dissolve,

first broken to small pieces. Pour on it six times its weight of the Vitriolic Acid, lowered as above directed, and set the matrafs in a sand-bath gently heated. The Zinc will dissolve entirely, without any sediment. The Neutral Metallic Salt resulting from this dissolution shoots into crystals, which go by the name of *White Vitriol*, or *Vitriol of Zinc*.

OBSERVATIONS.

THOUGH Zinc be soluble in all the Acids, and when combined with those Acids exhibits some uncommon phenomena, yet M. Hellot is the first that ever gave a particular account of what happens in those dissolutions: so that all we have to say on this head is extracted from that Gentleman's Memoirs. If a solution of Zinc in the Vitriolic Acid, prepared according to the directions in the process, be distilled from a retort placed in a sand-bath with a graduated heat, almost half the liquor presently comes over in pure phlegm. A small quantity of a Sulphureous Acid Spirit rises next. A greater force of fire is now requisite: the retort must therefore be removed into a reverberatory, and the distillation continued with a naked fire. On the first impression of this heat an odour of Liver of Sulphur discovers itself, which becomes sharp and suffocating towards the end of the distillation. In two hours time white vapours begin to appear, as in the rectification of common Oil of Vitriol. If the Receiver be then shifted, you will obtain an Oil of Vitriol, in quantity about the eighteenth part of the whole used in the distillation, which, though sulphureous, is yet so concentrated, that, if a few drops thereof be poured into a weak Oil of Vitriol, they fall to the bottom with as much noise as if they were so many bits of red-hot iron, and heat this Oil of Vitriol as much as common Oil of Vitriol heats water.

At the bottom of the retort there remains a dry, white, crystalline, saline mass, exceeding, in weight, the Zinc that was dissolved, about a twelfth part of the whole weight of the liquor. The increase of its weight is owing to a portion of the Vitriolic Acid that remains concentrated in the Zinc, and could not be expelled by the fire. This portion of Acid adheres to it most tenaciously: for, though M. Hellot kept the retort containing it during two whole hours in so violent a fire that the vessel began to melt, the smallest vapour did not rise from it.

This saline *Caput mortuum* is in the form of needles, much like the Sedative Salt. It is caustic, grows considerably hot when water is poured on it, and gives in the air, but slowly. Spirit of Wine, digested with this Salt for eight or ten days, acquires the same smell as that which is mixed with concentrated Oil of Vitriol in preparing Æther.

Zinc is dissolved by the Nitrous and Marine Acids, much in the same manner as by the Vitriolic; except that the Marine Acid does not touch a black, spongy, rarefied matter, which it separates from the Zinc. M. Hellot found upon trial that this matter is not Mercury, and that it cannot be reduced to a metallic substance.

That ingenious Chymist distilled likewise Solutions of Zinc in the Nitrous and Marine Acids. There came over at first, as there did from the solution made by the Vitriolic Acid, an aqueous, and then an acidulated liquor. At last, by exciting the fire with great violence, towards the end of the distillation, he obtained a small quantity of the Acid that had been employed in the dissolution: but the small portion of Acid thus obtained was exceeding strong; and the quantity of the Nitrous much more considerable than that of the Marine Acid.

A solution of Zinc in the Marine Acid, being distilled to dryness, yields a Sublimate on applying a violent heat to it.

All the Acids dissolve with ease, not only Zinc, but its Flowers also; and that nearly in the same quantity, and with almost all the same phenomena. Mr. Hellot, observing that the residues of most of the solutions of Zinc have a great resemblance with its Flowers, is of opinion that this semi-metal may be reduced, by the means of solvents, to the same state into which it is brought by the fire when limed in Flowers.

CHAP. IV.

Of ARSENIC.

PROCESS I.

To extract Arsenic from its Matrices. Zafre or Smalt.

POWDER some Cobalt, white Pyrites, or other Arsenical matters. Put this powder into a retort with a short wide neck, leaving a full third thereof empty. Set your retort in a reverberating furnace; lute on a receiver; heat your vessel by degrees, and increase the fire till you see a powder sublime into the neck of the retort. Keep up the fire in this degree as long as the sublimation continues: when this begins to slacken, raise your fire, and make it as strong as the vessels will bear. When nothing more ascends, let it go out. On unluting the vessels, you will find in the receiver a little Arsenic in the form of a fine light *farina*. The neck of the retort will be full of white flowers, not quite so fine, some of which will appear like little crystals; and if a good deal of Arsenic be sublimed, a ponderous matter, like a white, semi-transparent glass,

glafs, will be found adhering to that part of the neck of the retort which is next its body.

OBSERVATIONS.

ARSENIC is a metallic substance still more volatile than Zinc; so that it cannot be separated from the matters with which it is mixed, otherwise than by sublimation. It is proper, however, to take notice that it is not naturally in a metallic form, and that, properly speaking, the whole Sublimate obtained from Cobalt, as above directed, is nothing but a metallic calx, that cannot be brought to the form and gloss of a metal, till it be worked up with fatty matters, as we shall shew in its place.

This calx is of a very singular nature, and differs from every other metallic calx, in that this is volatile, and all the rest extremely fixed; even those procured from the semi-metals: for the Flowers of Zinc, which are justly considered as a calcined Zinc, tho' obtained by a sort of sublimation, are not for all that of a volatile nature, but rather exceedingly fixed; seeing they are capable of sustaining the most violent fire, and melt instead of subliming. Arsenic, on the contrary, is not only extracted from its ore by sublimation, but when once sublimed continues to be volatile, and flies off in vapours as soon as it is exposed even to a moderate degree of heat.

This metallic matter, before it is combined with the Phlogiston, is called *White Arsenic*, or plain *Arsenic*: it acquires the title of *Regulus of Arsenic* when it is united with the Phlogiston, and glisters like a metal.

Though Arsenic be volatile, yet it requires a pretty strong fire to separate it from the minerals containing it, especially in close vessels; because it adheres very close to earthy and vitrifiable matters. This adhesion is so firm, that, when thus combined,

it is capable of bearing a melting heat, and vitrifies with metallic calxes, and other fusible matters. On this account it is impossible to extract from Cobalt, or other Arsenical matters, all the Arsenic they contain by working them only in close vessels. If such matters are to be freed from all their Arsenic, you must, after you have extracted all they will yield by distillation, put them into a crucible, and set it uncovered in the midst of a strong fire. Many Arsenical vapours will still rise; and care must be taken to stir the contents of the crucible frequently with an iron rod, to facilitate the discharge of the remaining Arsenic.

It often happens that the Arsenic, obtained from minerals by sublimation, is not very white, but of a lighter or darker grey colour. This is owing to some particles of inflammable matter, from which Arsenical minerals are seldom quite free. A very small quantity of phlogiston is sufficient to deprive much Arsenic of its whiteness; and to give it a grey colour. But when fouled in this manner, it may easily be brought to its due degree of whiteness: it need only be sublimed once more, after mixing it with some substance on which it doth not act; Sea-salt, for instance. If the matters from which Arsenic is extracted contain Sulphur also, as some pyrites do, the Arsenic sublimes with much less heat, than when it is united with earthy matters only; because it combines with the Sulphur, wherewith it hath a great affinity, and the Sulphur serves to separate the Arsenic, by this interposition, from the earth. In consequence hereof, Sulphur may be employed to extract Arsenic out of the earths in which it is fixed. In this case, the Sulphur changes the colour of the Arsenic, which it makes of a lighter or deeper yellow, or even red, in proportion to the quantity there is of it, and to the degree of fire that hath acted on both together.

The consistence of Arsenic is different, according to the degree of heat applied in subliming it. If the Arsenical vapour meet with a cold place, it gathers there in the form of a powder, as the Flowers of Sulphur do: this is the case with that which falls into the receiver in distilling it. But, if it be stopped in a hot place, and cannot escape from that heat, it condenses into a heavy, compact, semi-transparent body, having undergone the first degree of fusion.

Yet it cannot be perfectly melted, so as to flow like other fused matters: not that it is refractory; for, on the contrary, the degree of heat in which it begins to melt is very moderate, and it is in its own nature very fit to promote the fusion of refractory matters: but the reason is this; it is necessarily converted into vapours by the degree of heat necessary to fuse it, and these vapours burst the vessels, if they find no vent.

Arsenic made yellow by a mixture of Sulphur, which is also called *Orpiment*, is reducible to the form of a solid Sublimate with more ease; because it is alloyed with a twentieth, or perhaps a tenth part, of its weight of Sulphur, which renders it more fusible.

Red Arsenic, which contains still more Sulphur, melts also more easily. It then becomes of a transparent red, like a ruby: and hence, when it is in this form, it is called *Ruby of Arsenic*.

When a combination of Sulphur and Arsenic is wanted, it is better to mingle and distill together such minerals as contain Sulphur and Arsenic, the white and the yellow pyrites, for instance, than to mingle pure Arsenic with pure Sulphur: for the great volatility of these two substances is a hindrance to their uniting; whereas, when combined with other matters, they are capable of sustaining a much greater degree of heat, which favours and promotes their union.

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Those who work by the great do not extract Arsenic out of Cobalt by distillation: they throw the ore mixed promiscuously with wood and charcoal into a great furnace, from whence a flue carries the vapours into a long winding passage, across which beams of wood are fixed at proper distances from each other. The Arsenical vapours being conducted into this passage, adhere both to the sides thereof and to the joists that lye across it. The fuliginous parts of the combustible matters being lighter ascend higher, and go out through a chimney at the farther end of this passage.

The Arsenic sublimed by this method is not white, but of a grey colour; owing to the inflammable matter of the wood and charcoal, with which the ore is torrefied.

When all the Arsenic the Cobalt will yield is thus separated, the earthy fixed matter left behind is mixed with divers fusible matters and vitrified, and produces a glass of a beautiful blue colour. It is called *Smalt*. This glass is to be prepared in the following manner.

Take four parts of fine fusible sand, an equal quantity of any Fixed Alkali perfectly depurated, and one part of Cobalt from which the Arsenic hath been sublimed by torrefaction. Pulverize these different substances very finely, and mix them thoroughly together; put the mixture into a good crucible, cover it, and set it in a melting furnace. Make a strong fire, and keep it up constantly in the same degree for some hours. Then dip an iron wire into the crucible; to the end of which a glassy matter will stick, in the form of threads, if the fusion and vitrification be perfect. In this case take the crucible out of the fire; cool it by throwing water on it, and then break it. You will find in it a glass, which will be of an exceeding deep blue, and almost black, if the operation hath succeeded.

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This glass, when reduced to a fine powder, acquires a much brighter and more lively blue colour.

If you find after the operation that the glass hath too little colour, the fusion must be repeated a second time, with twice or thrice the quantity of Cobalt. If, on the contrary, the glass be too dark, less Cobalt must be used.

Instead of the mixture here prescribed you may employ a ready-made glass, provided it be white and fusible. But as glass is always hard to melt, and as the mixing Cobalt with it renders it still more refractory, therefore though an Alkaline Salt be one of the ingredients in its composition, it is proper to promote the fusion, by mixing therewith calcined wine-lees, in the quantity of one third part of the weight of the Cobalt.

In order to make the assay of a particular Cobalt, with a view to know what quantity of blue glass it will yield, it is not necessary to perform the operation in the manner here set down; a great deal of time and trouble may be saved by melting one part of Cobalt with two or three parts of Borax. This Salt is very fusible, and turns, when melted, into a substance which, for a time, possesses all the properties of glass. In this trial the glass of Borax will be nearly of the same colour as the true glass, or Smalt, made with the same Cobalt.

The ores of Bismuth, as well as Cobalt, yield a matter that colours glass blue; nay, the Smalt made with those ores is more beautiful than that procured from the ore of pure Arsenic. Some Cobalts yield both Arsenic and Bismuth. When such Cobalts are used it is common to find at the bottom of the crucible a little button of metallic matter, which is called *Regulus of Cobalt*. This *Regulus* is a sort of Bismuth, generally adulterated with a mixture of ferruginous and arsenical parts.

The heaviest and most fixed Flowers of Arsenic, procured from Cobalt, have likewise the property of giving a blue colour to glass. But this colour is faint : it is owing to a portion of the colouring matter carried up along with the Arsenic. These Flowers may be made an ingredient in the composition of blue glass, not only because of the colouring principle they contain, but also because they greatly promote fusion ; Arsenic being one of the most efficacious fluxes known.

In short, all those blue Glasses, or Smalts, contain a certain quantity of Arsenic ; for a portion of this semi-metal always remains united with the fixed matter of the Cobalt, though roasted for a long time, and in a very hot fire. The portion of Arsenic that is thus fixed vitrifies with the colouring matter, and enters into the composition of the Smalt.

The blue glass made with the fixed part of Cobalt hath several names, according to the condition in which it is. When it hath undergone the first imperfect degree of fusion only, it is called *Zaffre*. It takes the name of *Smalt* when perfectly vitrified : and this again being pulverized is called *Powder-Blue* ; or, if finely levigated, *Blue Enamel* ; because it is used in enamelling, as well as in painting earthen-ware and porcelain.

P R O C E S S II.

To separate Arsenic from Sulphur.

POWDER the yellow or red Arsenic which you intend to separate from its Sulphur. Moisten this powder with a Fixed Alkali resolved into a liquor. Dry the mixture gently ; put it into a very tall glass cucurbit, and fit on a blind-head. Set this cucurbit in a sand-bath ; warm the vessels

fels gently, and increase the fire by degrees, till you perceive that no more Arsenic sublimes. The Arsenic, which before was yellow or red, rises into the head partly in white flowers, and partly in a compact, white, semi-transparent matter, which looks as if it were vitrified. The Sulphur combined with the Fixed Alkali remains at the bottom of the cucurbit.

OBSERVATIONS.

A FIXED Alkali hath more affinity than any metallic substance with Sulphur: so that it is not surprising Sulphur should be separated from Arsenic by its interposition. Yet there is an inconvenience attends the use of it: for it hath a great affinity with the Arsenic also, and so always retains some part thereof, which continues fixed with it. For this reason care should be taken not to mix, with sulphurated Arsenic, a greater quantity of Alkali than is necessary to absorb the Sulphur it contains. Nothing however, but experience and repeated trials can teach us the exact quantity of Alkali that ought to be employed; because the quantity of Sulphur that may be contained in yellow or red Arsenic is indefinite.

The vessel ought to be tall, that the upper part of the head, where the Arsenical particles condense, may be the less exposed to heat. Towards the end of the operation the fire must be strongly excited, so as to make the sand red-hot; because the last portions of Arsenic that rise are strongly retained by the Fixed Alkali.

Arsenic that is grey or blackish may be depurated and whitened by the same means; because a Fixed Alkali absorbs the phlogiston likewise with great avidity. Mercury, as well as a Fixed Alkali, is an excellent additament for separating Arsenic from Sulphur. If you will use it for that purpose, reduce the

the sulphurated Arsenic to a very fine powder, by rubbing it a long time in a glass mortar; when it is well pulverized, let a few drops of Mercury fall upon it, by squeezing it through chamoy, and continue the trituration. The yellow or red colour of the Arsenic will insensibly change, and gradually grow darker as the Mercury incorporates with it. When the Mercury is perfectly killed, add a little more of it than you did the first time, and in the same manner: continue to triturate till it disappear; and thus go on adding more and more till the Mercury you add remain quick, and you can kill no more of it. Neither the red nor the yellow colour will then appear in the mixture; which will be grey, if it contain but a little Sulphur, and black, if a great deal.

Put this mixture into a very tall glass cucurbit; fit on a blind-head; set it in a sand-bath, and bury it in the sand as far as the contained mixture reaches. Heat the vessels, and, during the whole operation, keep up a degree of fire a little weaker than that required for subliming Cinabar. White Arsenical Flowers will adhere to the upper part of the head, amongst which will be some beautiful crystals of Arsenic; and underneath them you will find some Cinabar sublimed, but not entirely free from Arsenic. If you desire to have your Cinabar and your Arsenic purer, and more unmixed with each other, separate the upper sublimate, which is Arsenical, from the lower, which consists chiefly of Cinabar. Powder each of them coarsely, and sublime them separately each in a different cucurbit.

On this occasion the Mercury separates the Sulphur from the Arsenic, because it hath a greater affinity than Arsenic with that mineral. It is not the only metallic substance of this character: for, as hath been shewn, there are several others that have a greater affinity than Mercury with Sulphur, being
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able to decompose Cinabar by their interposition. Yet those metallic substances must not be substituted for Mercury in the present operation; because there is none of them but hath at the same time a very great affinity with Arsenic, or even as strong an one as they have with Sulphur; whereas Mercury will by no means unite with Arsenic.

This method of separating Arsenic from Sulphur hath two advantages over that in which a Fixed Alkali is the medium. The first is, that by this means all the Arsenic contained in the mixture is extracted out of it; and the second, that, as Mercury doth not absorb Arsenic, we are not put to the trouble of groping out, as it were, by trials the quantity necessary to be added; and that, though more be added than is necessary to absorb all the Sulphur, it will be of no prejudice to the operation. But then it is attended with the inconvenience of being much more tedious and more laborious than the other. For, in the first place, it requires previously a very tiresome trituration, in order to procure an union between the Sulphur and the Mercury, and so to form an *Æthiops*; without which the Mercury and the sulphurated Arsenic will sublime separately, so that no decomposition will be effected. Secondly, though the Mercury be sufficiently united with the Sulphur of the Arsenic by the long trituration that precedes the sublimation, this doth not prevent, as we took notice above, the sublimed Arsenic and Cinabar from being in some measure blended together; so that each requires a second separate sublimation to render it very pure:

These inconveniences cause a Fixed Alkali to be used preferably to Mercury; the loss of a small quantity of the Arsenic, which remains united with the Alkali, being little regarded; as that metallic substance is neither scarce nor precious,

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When Arsenic is united with a great quantity of Sulphur, it may be freed from a part thereof without the intervention of any third body: it is sufficient for the purpose to sublime it with a very gentle fire, increased by insensible degrees. The most sulphureous part ascends first; what arises afterwards is more Arsenical, and less sulphureous; and the last flowers of all are pure Arsenic, or at least nearly so.

PROCESS III.

To give Arsenic the Metalline Form., Regulus of Arsenic.

TAKE two parts of white Arsenic in fine powder, one part of the black flux, half a part of Borax, and as much clean iron filings. Rub the whole together, in order to mix them thoroughly. Put this mixture into a good crucible, and over it put Sea-salt three fingers thick. Cover the crucible; set it in a melting furnace; and begin with a gentle fire to heat the crucible equally.

When arsenical vapours begin to ascend from the crucible, raise the fire immediately so as to melt the mixture. Examine whether or no the matter be thoroughly melted, by introducing an iron wire into the crucible; and if the fusion be perfect, take the crucible out of the furnace. Let it cool; break it; and you will find in it a Regulus of a white and livid metallic colour, very brittle, scarcely hard, but rather friable.

OBSERVATIONS.

WHITE Arsenic is, as hath been said, a metallic calx; and consequently wants no more, in order to its acquiring the metalline properties, than to be
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combined with the phlogiston: this is effected by the operation before us.

The Iron added doth not serve here, as in making the Regulus of Antimony, to precipitate the Regulus of Arsenic, by separating it from some other substance with which it was united: on this occasion it does nothing but join the Regulus of Arsenic, to which it gives solidity and consistence. This is the only reason of its being made an ingredient in the mixture; as the Regulus of Arsenic, without it, would have such a tender consistence, that it could scarce be handled without falling asunder into little bits. The Iron procures a further advantage in this process; which is, that it prevents a great quantity of Arsenic from being lost in vapours: for the Arsenic, with which it combines, is restrained, and, in some measure, fixed by it.

Copper may be substituted for Iron, and procures the same advantages.

It is very necessary to remove the crucible from the fire as soon as the matter is melted, and indeed to cool it as expeditiously as possible, to prevent the Arsenic from flying off in vapours: for, when once the Regulus is formed, the proportion of Arsenic, with respect to that of the metal mixed with it, is continually lessening while it stays in the fire; so that, after some time, there will be left in the crucible, not a Regulus of Arsenic, but only Iron or Copper, alloyed with a little Arsenic. On this occasion the Copper turns white, and assumes the colour of Silver; but it soon tarnishes in the air.

It is easy to perceive, by what hath been said, that the Regulus of Arsenic made according to this process is never pure, but contains always a considerable quantity of Iron or Copper, whatever precautions be used: but it is difficult to avoid this inconvenience, for the reasons above assigned; and if we attempt to fuse Arsenic alone, with reducing

fluxes, the greatest part thereof is dissipated in vapours, long before the very flux begins to melt: and that part of it, which is found metallized, is not collected in one mass at the bottom of the crucible, as in other metallic reductions; but in small particles, dispersed and mixed among the scorixæ. There are nevertheless several expedients for obtaining a Regulus of Arsenic absolutely pure, and unalloyed with any metallic substance.

First: into a little low cucurbit, covered with a blind-head, put Regulus of Arsenic made with Iron or Copper; set this cucurbit in a sand-bath; heat it till the sand begins to grow red; and you will see part of the Regulus sublime into the head, still retaining its metallic splendour. The portion of Regulus thus sublimed is pure Arsenic, or at least contains but a very small portion of the adventitious metal, which may have been carried up with it. What is left in the bottom of the cucurbit is the metal that was added, still containing a little Arsenic, which continues obstinately fixed with it, and which the violence of fire is unable to force away from it in close vessels.

Secondly: mix your Arsenic in equal parts with the black flux; put the mixture into such a cucurbit as that last mentioned; and apply to it the strongest degree of heat that can be procured by a sand-bath: arsenical flowers, of a blackish grey colour, will first sublime into the head, and after them a Regulus of Arsenic of a white metalline colour, which is pretty glossy, but tarnishes very soon in the air. This Regulus hath no solidity: it is exceeding friable; but it is pure.

Thirdly: I have also made a Regulus of pure Arsenic by another method, which produces a much greater quantity thereof, with a much smaller degree of heat. For this purpose I powder the Arsenic and mix it with any Fat Oil; so that the mixture
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may be like a liquid paste: this paste I put into a little phial of thin glass, like one of those used by apothecaries; I set this phial in a sand-bath, and gradually heat it, till the bottom of the pot containing the sand begin to be red. Part of the Oil first rises out of the phial in vapours, which must be suffered to pass off. After this the upper part of the phial is gradually lined, on the inside, with a glittering metallic crust, which makes it look like a quick-silvered glass. This crust is the Regulus of Arsenic. When it begins to sublime, the mouth of the phial must be slightly stopped with a bit of paper, and the heat increased a little, till you see that nothing more rises.

If you break the bottle after the operation, you will find its upper part crufted over with a coat of Regulus, thicker or thinner in proportion to the quantity of Arsenic employed. The Regulus is in a mass, of a beautiful brilliant colour, which to me seems to stand the air better than that of any Regulus made by other methods; probably because of the great quantity of fat matter with which it is united, and by which it is defended.

This Regulus of Arsenic is absolutely pure, and a much greater quantity thereof is obtained, by this method, than by treating it with the black flux; because the Arsenic is much sooner and more easily combined with the inflammable matter: and hence it comes to pass that part of the Arsenic doth not rise at first in grey flowers, as in operating with the black flux. Moreover, by our process, all the Arsenic is sublimed in Regulus: whereas, when the black flux is employed, a pretty considerable part of the Arsenic unites with the alkaline part of the flux, and remains fixed therewith. In our operation there is nothing left at the bottom of the phial, except an oily, light, but very fixed coal.

Regulus of Arsenic, in whatever manner made, may be easily reduced into white, crystalline Arse-

nic, by the means of a Fixed Alkali, or of Mercury, applied in the same manner as for separating Arsenic from Sulphur.

PROCESS IV.

To distill the Nitrous Acid by the interposition of Arsenic. Blue Aqua Fortis. A new Neutral Salt of Arsenic.

PULVERIZE finely any quantity you please of refined Salt-petre. Mix it accurately with an equal weight of white crystalline Arsenic, well pulverized, or else with very white and very fine flowers of Arsenic. Put this mixture into a glass retort, leaving one half of it empty. Set your retort in a reverberating furnace; apply a receiver having a small hole drilled in it, and containing a little filtered rain-water; lute the receiver to the retort with stiff lute. Begin with putting two or three small live coals in the ash-hole of the furnace, and replace them with others when they are ready to go out. Go on thus warming your vessels by insensible degrees, and put no coals in the fire-place till the retort begin to be very warm. You will soon see the receiver filled with vapours of a dark-red, inclining to a russet colour. With a bit of lute stop the little hole of the receiver. The vapours will be condensed in the water of this vessel, and give it a very fine blue colour, that will grow deeper and deeper as the distillation advances. If your Salt-petre was not very dry, some drops of Acid will also come over, and falling from the nose of the retort mix with the water in the receiver. Continue your distillation, increasing the fire little by little as it advances, but exceeding slowly, till you see

see that when the retort is red-hot nothing more comes off; and then let your vessels cool.

When the vessels are cold, unlute the receiver, and, as expeditiously as you can, pour the blue *Aqua Fortis* it contains into a crystal bottle; which you must seal hermetically, because this colour disappears in a short time when the liquor takes air. You will find in the retort a white saline mass moulded in its bottom, and some flowers of Arsenic sublimed to its upper cavity, and into its neck.

Pulverize the saline mass, and dissolve it in warm water. Filter the solution, in order to separate some arsenical parts that will be left on the filter. Let the filtered liquor evaporate of itself in the open air; when it is sufficiently evaporated, crystals will shoot in it representing quadrangular prisms, terminated at each extremity by pyramids, that are also quadrangular. These crystals will be in confused heaps at the bottom of the vessel: over them will be other crystals in the form of needles; a saline vegetation creeping along the sides of the vessel; and the surface of the liquor will be obscured by a thin dusty pellicle.

OBSERVATIONS.

ARSENIC, as we took notice in our Elements of the Theory, besides the properties it hath in common with metallic substances, possesses others also in common with saline substances. One of the most remarkable among the latter is that of decomposing Nitre; of expelling the Acid of that Salt from its Alkaline basis, assuming its place, and forming with that Alkali a Neutral Salt, which is very soluble in water, and shoots into regular crystals.

To enquire into what passes in the decomposition of Nitre by Arsenic, and into the new Salt resulting from thence, was the design of the first Memoir given in by me to the Academy of Sciences on this

subject, and from that the present process is copied. Though the whole quantity of Arsenic prescribed in the process doth not enter into the composition of the new Neutral Salt; seeing some of it sublimes in flowers, that quantity must not therefore be thought too great; for we see, on the other hand, that part of the Nitre is not decomposed. The needle-like Salt is no other than Nitre that hath not suffered any decomposition, and actually deflagrates on live coals like common Nitre.

The precaution of putting some water in the receiver is absolutely necessary, to condense the nitrous vapours that rise in the distillation: for they are so elastic, so volatile, so dephlegmated, that a very small part of them will otherwise be condensed into a liquor, while the rest will remain in the form of vapours, to which vent must be given through the small hole in the receiver, as without that they will burst the vessels with impetuosity: and consequently scarce any Acid will be obtained; especially if the Nitre employed be very dry, as it must be to be reducible into a fine powder.

The blue colour communicated by the Nitrous Acid to the water is very remarkable. The cause that produces this colour is not yet known.

Though the Acid is, on this occasion, mortified by a great quantity of water, yet, when it rises out of the retort, it is so concentrated as to form, even with that water, if too much be not put in, a most active and even smoaking *Aqua Fortis*.

It is necessary in this operation, and more so than in any other, to warm the vessels gradually, and to proceed exceeding slowly; otherwise the Artist runs the risque of seeing his vessels burst to pieces with violence, and with great danger to his person: for Arsenic acts on Nitre with incredible vivacity; in so much that, if a mixture of Nitre and Arsenic be heated to a certain degree, the Nitre is decomposed

almost as rapidly, and with as great an explosion, as when it is made to fulminate with an inflammable matter. In short, the appearances are such, that one would be almost induced to think the Nitre really takes fire on this occasion; though it be only decomposed just as it is by the Vitriolic Acid.

The solution of the *caput mortuum* of this distillation contains, at the same time, several sorts of Salts: to wit, 1. the Neutral Salt of Arsenic, formed by the union of the Arsenic with the basis of the Nitre; this shoots into the prismatic crystals above mentioned: 2. some Nitre that hath not been decomposed; this forms the needles and part of the vegetations: 3. a small portion of Arsenic, that is known to be soluble in water; this forms the thin dark pellicle that covers the surface of the liquor when it begins to evaporate.

For the properties of this new Neutral Salt of Arsenic you may consult what we have said thereupon in our Elements of the Theory, and in the Memoirs of the Academy of Sciences.

P R O C E S S V.

To alkalizate Nitre by Arsenic.

ME L T in a crucible the Nitre you intend to alkalizate. When it is melted, and moderately red, project upon it two or three pinches of pulverized Arsenic. A considerable effervescence and ebullition will immediately be produced in the crucible, attended with a noise like that which Nitre makes, when it detonates with an inflammable matter. At the same time a thick smoke will rise, which at first will smell like garlick, the odour peculiar to Arsenic; it will also smell afterwards like Spirit of Nitre. When the effervescence in the

crucible is over, throw again upon the Nitre as much pulverized Arsenic as you did the first time; and all the same phenomena will be repeated. Continue thus throwing in Arsenic in small parcels, till it produce no more effervescence; taking care to stir the matter at every projection with an iron wire, the better to mix the whole together. Then encrease your fire, and melt what remains. Keep it thus in fusion for a quarter of an hour, and then take the crucible out of the fire. It will contain a Nitre alkalized by Arsenic.

OBSERVATIONS.

THIS operation, as well as the preceding one, is a decomposition of Nitre by Arsenic; yet the result is very different: for, instead of a Salt capable of crystallizing, and discovering no tokens either of Acid or Alkali, we obtain, on this occasion, only a Salt that runs into a liquor by the moisture of the air, doth not crystallize, and hath all the properties of an Alkali.

These differences arise only from the different manner in which the decomposition of the Nitre, and the union of the Arsenic with the basis of that Salt, is brought about. When the Nitrous Acid is distilled by the interposition of Arsenic, with a view to obtain the Arsenical Salt, the operation must be performed in close vessels; no greater degree of heat must be applied to the mixture than is necessary for enabling the Arsenic to act; and that heat must be administered very slowly and by insensible degrees. But, when the business is to alkalize Nitre by the means of Arsenic, the operation is performed in a crucible, in a naked fire, with a strong degree of heat, and that suddenly applied. The violence of the heat, the suddenness with which it is applied, the vivacity wherewith the Arsenic unites with the basis of the Nitre; and, still more than all these, the free
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access of the air, occasion the greatest part of the Arsenic, which at first combines with the basis of the Nitre after having expelled its Acid, to be presently carried off and dissipated in vapours; and consequently the basis of the Nitre, not being sufficiently saturated, discovers its Alkaline properties.

I say the concurrence of the air contributes, still more than all the rest, to separate the Arsenic from the Alkaline basis of the Nitre; experience having taught me that the Neutral Salt of Arsenic is not to be alkalized by the most violent force of heat, as long as it continues in close vessels, and the external air hath no communication with it; but that some of the Arsenic contained in that Salt is dissipated, by exposing it to a strong heat in open vessels.

The tumult and effervescence that arise, when Arsenic is projected on Nitre fused in a crucible, are so considerable, and so nearly resemble the detonation of Nitre with an inflammable matter, that we should be tempted to think, if we trusted appearances only, that Arsenic furnishes a combustible matter, and that the Alkalization of the Nitre is effected, on this occasion, in the same manner as when it is fixed by charcoal: but, by examining attentively what passes, we easily discover that there is no inflammation at all, and that the Nitre is alkalized in the manner and by the means above pointed out.

The first vapours that rise, when Arsenic is projected on Nitre, are purely arsenical; and, if any cold body be put in their way, they adhere to it in the form of flowers. These vapours are actual particles of Arsenic, carried up by the heat before they could come to act on the Nitre; but they are soon after mixed with nitrous vapours, consisting of the Acid of the Nitre, which the Arsenic expels from its basis as fast as it comes to act on that Salt.

The nearer you come to the end of the operation, the more does the matter in the crucible lose of its fluidity, though an equal fire be constantly kept up in the furnace. At last it becomes quite like a paste, and the fire must be made much stronger to put it again in fusion. The reason of this is, that Nitre when alkalized is much less fusible than when it is not so. The case is the same when this Salt is alkalized by deflagration.

Though the Nitre, when alkalized, makes no more effervescence with Arsenic, and though, when kept in fusion, it emits no more arsenical vapours, it doth not thence follow that it is a pure Alkali, and that it contains no Arsenic: it still contains a large quantity thereof, but so strongly united that the force of fire is not able to separate them; which hath led some authors to give this Salt the title of *Fixed Arsenic*.

The existence of Arsenic in this saline compound is easily discovered, by fusing it with metallic substances, on which it produces the same effects as Arsenic.

With solutions of metals in the Acids, it also presents almost the same phenomena as the Neutral Salt of Arsenic. Particularly it precipitates Silver dissolved by the Nitrous Acid in a red powder, as that Salt does; and the differences observed between the precipitations made by our new Neutral Salt of Arsenic, and those made by Nitre alkalized with Arsenic, can be attributed only to the Alkaline quality of the latter. See the Memoirs of the Academy for 1746.

PART II.
OF VEGETABLES.

SECTION I.

Operations on unfermented Vegetables.

CHAP. I.

OF THE SUBSTANCES OBTAINED FROM VEGETABLES BY EXPRESSION ONLY.

PROCESS I.

To express and depurate the Juice of a Plant, containing its Essential Salt. The Crystallization of that Salt.

BEFORE sun-rise, gather a good quantity of the plant from which you design to express the juice, in order to obtain its Salt. Wash it well in running water, to clear it of earth, insects, and other adventitious matters. Bruise it in a marble mortar; put it into a bag of new, strong, thick linen cloth; tye the bag tight, and commit it to a press. By pressing it strongly you will squeeze out a great quantity of green, thick juice, which will have the same taste as the plant. Dilute this juice with six times as much pure rain-water, and filter it repeatedly through a woollen bag, till it pass clear and limpid. Evaporate the filtered juice with a gentle

gentle heat, till it be almost as thick as before it was mixed with water. Put this inspissated juice into a jar, or other vessel of earth or glass; on its surface pour olive oil to the depth of a line, and set it in a cellar. Seven or eight months after this, pour off gently the liquor contained in the vessel, the inside of which you will find covered with a crystallized Salt. Separate the crystals gently; wash them quickly with a little fair cold water, and dry them: this is the Essential Salt of the plant.

OBSERVATIONS.

EVERY plant is not equally disposed to yield its Essential Salt, by the method here proposed. Succulent vegetables only, whose juices are aqueous and not too viscous, are fit for this purpose. Such for example as sorrel, brook-lime, fuccory, fumitory, water-creffes, plantain, &c. An Essential Salt cannot be procured from those that yield thick, viscid, mucilaginous juices, such as the seeds of fleawort; unless their juices be previously attenuated by fermentation, and that viscosity destroyed which obstructs the Crystallization of this Salt.

Nor can the Essential Salt be obtained in any quantity from vegetable matters abounding in oil. Most kernels and seeds are of this sort: they all contain a great quantity of fat oil, which so entangles and clogs this Salt, that the particles thereof cannot shoot away from the tenacious juices into crystals.

The same is to be said of dry aromatic plants; because they contain much essential oil, or resinous matters that produce the same effect. It is true the Essential Salt itself contains a certain portion of oil; for it is no other than the Acid of the plant incorporated and crystallized with part of its oil and of its earth: but then the oil must not be in too great a quantity; because it sheaths the Acid, renders it clammy, as it were, and hinders it from extricating
itself,

itself, so as to be able to exert its qualities, and appear in the form of Salt.

The plants, from which you intend to extract this Salt, should be gathered in the morning before sunrise; because they are then most succulent, not being yet dried up or withered by the heat of the Sun.

The juice of plants obtained by expression is very thick; because it contains many particles of the bruised plant, that are unavoidably squeezed out along with it. In order to clear it of these superfluous parts, it is proper to filter it; but as that would be difficult, on account of the thickness of the juice, it must be thinned, by diluting it with a quantity of water, sufficient to give it the requisite degree of fluidity.

Instead of thus diluting the expressed juice, the plant may be ground with water, before it is put into the press: it will by this means furnish a more fluid juice, that will easily pass through the filter. This method may be employed with success on dry plants, or such as are not very succulent. For this operation rain-water is to be preferred to any other; because it is the purest: for all waters that have run some time through the earth, or on its surface, are to be suspected of containing some saline or selenitic matter, which would mix with and deprave the Essential Salt.

The juice of the plant, when diluted with the quantity of water sufficient to facilitate its filtration, is too aqueous to let the Salt it contains unite into Crystals: it must therefore be evaporated, till it hath recovered a somewhat thicker consistence. The heat applied for that purpose must be gentle; lest the Acid and oily parts, that are to form the Salt, be spoiled or dissipated, as they are not very fixed. In summer, the heat of the sun is sufficient to effect this evaporation: but if you make use of this method, the juice to be evaporated must be put into
several

several broad flat pans; that, a larger surface being exposed to the action of the air and sun, the evaporation may be the sooner completed: for if the juice should continue too long in the degree of heat requisite for its evaporation, it might begin to ferment; which would be very detrimental.

The oil poured on the liquor prevents its fermenting, putrefying, or growing mouldy, during the long space of time required for the Crystallization of the Essential Salt.

These Salts are excellent Medicines; being endowed with the same virtues as the plants from which they were obtained.

They cannot be procured from plants by distillation, though they consist in a great measure of volatile principles: nor are they obtainable by any other process that requires much heat; because they are easily decomposed, and the fire changes their natures entirely. The oily Acids extracted from plants by distillation do not crystallize, and always have an empyreumatic acrimony, that makes them very different from the Essential Salts, which are very mild and saponaceous.

PROCESS II.

To draw the Oils out of Kernels, Seeds, and Fruits, by Expression.

POUND in a marble mortar, or grind in a mill, the kernels, seeds, or fruits, out of which you intend to express the Oil. If your matters be meagre, and grind to meal, suspend that meal in the steam of boiling water, in order to moisten it a little, and then dry it.

Tye up your matter thus prepared in a new, strong, thick, canvass bag, and put it into a press, between two iron plates previously heated in boiling water: squeeze it strongly, and you will see the Oil run in streams into the receiving vessel.

OBSERVE

OBSERVATIONS.

THE Fat Oil of Plants is particularly found in kernels, seeds, and some fruits; some kernels contain such a vast quantity thereof, that, on being very slightly bruised in a mortar, they discharge it in great abundance. Sweet and bitter Almonds, Walnuts, and Lint-feed, are all of this kind; and require no other management, but to be pounded and pressed, to make them yield a great deal of Oil. But there are others more meagre, that being ground produce an almost dry flour. In order to facilitate the expression of the Oil out of such, they must be exposed, when ground, to the steam of boiling water. For this purpose the meal may be put into a fine sieve, and that suspended over a pan half-full of water kept boiling on the fire. The ascending vapours will moisten the flour, render it more unctuous, and facilitate the expression of the Oil.

It is proper to dry it a little before it be put into the press, that it may yield as little water as possible along with the Oil. Nevertheless, so much water happens now and then to be left in it, that some is expressed together with the Oil: but as oil and water do not incorporate, they are easily separated after the operation is finished.

The extraction of the Oil is also greatly facilitated by heating the plates, between which the oleaginous matters are squeezed: but they must not be made too hot, if you mean to have a very mild Oil, designed either for aliment or for medicine; such as the Oil of olives, and that of sweet almonds. For this reason the plates must be warmed in boiling water only: if you heat them to a greater degree, you run the risque of giving an acrimony to the Oils you express. But, when these Oils are intended for other uses, the plates may be made hotter, because their heat increases the yield of Oil.

It is remarkable that all the Oils obtained by expression, with the precautions above recommended, are constantly very mild; even though the matters from which they are extracted be in themselves very acrid. Mustard-seed, which is so acrid that it is even caustic, yields, by expression, an Oil as mild as that of sweet almonds. But then the kernels, seeds, and fruits, from which the Oils are extracted, must not be old; because these Oils, which are perfectly mild when fresh, and new, become intolerably acrid when they grow old, and acquire this acrimony even in the fruit itself; for it is observed that these fruits turn rancid as they grow old.

The Fat Oils obtained by expression are used in medicine, both internally and externally, as Lenitives and Emollients. Every body knows the great use of Oil of sweet almonds, in inflammatory distempers of the breast and intestines. But it must be carefully noted, that these Oils can produce no good effects, unless they be fresh expressed, and from fruits, kernels, or seeds that have not been long kept: for they not only lose their lenient virtue by growing old; but they even acquire an opposite quality, and contract such a sharp acrimony, that far from procuring any salutary relief or mitigation to the inflamed parts, they are capable of irritating and inflaming the sound.

It is therefore of the last importance to administer them only when they are quite fresh: they ought never to be above two or three days old. Those that are old are generally more limpid and transparent than the fresh, which look a little more cloudy. The best way to distinguish them is to taste them, and to try whether or no they leave any sensation of rancidity on the palate and in the throat.

PROCESS III.

*To draw the Essential Oils of certain Fruits
by Expression.*

TAKE the rind of a Citron, Lemon, Orange, Bergamot-Pear, or other fruit of that kind; cut it in slices, and, doubling the slices, squeeze them between your fingers, over against a polished glass set upright, with its lower end in a vessel of earth or porcelain. Every time you squeeze the peel in a new ply, there will squirt out of it several fine jets of liquor, which, meeting with the surface of the glass, will be condensed into drops, and trickle down in small streams into the recipient. This liquor is the Essential Oil of the fruit.

OBSERVATIONS.

No fruits but those of the kind above-mentioned will yield an Essential Oil by expression. The rind of the fruit is the reservoir of this Oil: it is contained in little vesicles, which may be seen by the naked eye, spread all over the surface of the peel, and which, bursting when the peel is squeezed, discharge the Oil in the form of very fine slender spouts. Every body knows that these little oily streams instantly take fire, when spirted through the flame of a candle: the Oil in this case is entirely consumed.

The Essential Oil; thus obtained by expression, hath a very sweet and most agreeable scent. It is in every respect the same as when it made a part of the fruit that yielded it; seeing it hath not undergone the action of fire. Yet this method, however good it may be, can hardly be practised but in the countries where those fruits are in great plenty; because we cannot by this means obtain any thing near the quantity of Oil they contain.

This inconvenience may be remedied by rubbing the rind, which contains the Essential Oil, on the surface of a sugar-loaf. The inequalities of that surface produce the effects of a rasp, by tearing all the oily vesicles. The Oil, which issues in abundance, is imbibed by the sugar and moistens it. When the sugar is sufficiently impregnated therewith, it may be scraped off with a knife, and put into a well-stopped bottle. The sugar does not alter the nature of the Oil; which may be kept in this manner for years, and used, though combined with the sugar, for almost all the same purposes as when in a fluid state; that is, to aromatize the several matters with which you incline to mix it. We owe these observations to M. Geoffroy.

This experiment, in which the Essential Oil of a vegetable is obtained by expression alone, and without the aid of fire, proves that the Oils of this kind exist naturally in vegetables; and that the Oils of the same kind obtained by distillation, as shall be shewn in its place, are not the product of the fire. Essential Oils drawn by expression do not very sensibly differ from those procured by distillation.

C H A P. III.

OF THE SUBSTANCES OBTAINED FROM
VEGETABLES BY TRITURATION.

P R O C E S S I.

To make the Extract of a Plant by Trituration.

BRUISE the vegetable substance of which you intend to make the Extract; or, if it be hard and dry, grind it to a powder: put the matter thus prepared, together with seven or eight times as much rain-water, into an earthen vessel; and into this vessel fit a churning-staff, so that it may be continually whirled round with a rotatory motion, by means of a cord, a wheel, and a winch. Ply this machine for ten or twelve hours; and then filter the liquor through two linen cloths spread on a hair-sieve. Let your filtered liquor stand quiet for twelve hours more: then pour it off by inclination from the sediment you will find at bottom; and filter it a second time through a flannel bag.

Pour fresh water, but in a smaller quantity, on the mass left after trituration with the machine. Triturate it again for four or five hours. Treat the liquor of this second triture just as you did that of the first, and mix them both together. Distribute all the liquor you now have among a sufficient number of shallow earthen plates, and evaporate it by a gentle warmth, such as that of the sun, or of a vapour-bath, to the consistence of an Extract, or even to dryness, as you think proper.

OBSERVATIONS.

IN trituration the water takes up, not only the Salts of plants, but also a pretty considerable quantity of their oily and earthy parts, which those Salts have rendered soluble therein, by communicating to them a saponaceous and mucilaginous quality. After trituration therefore nothing remains but the grossest particles of oil and earth. Hence it is evident that the water, in which plants have been triturated, contains nearly the same principles as the juices of those plants drawn by expression; and that it is also impregnated with their Essential Salts: so that, by evaporating it to a due consistence, we have a well-made Extract of the triturated plant.

The Count de la Garaye, who hath long cultivated, with great assiduity, those parts of Chymistry by which Medicine may be improved, hath made a great number of experiments for obtaining from plants, by triture with water, the matters in which their virtues chiefly reside, and hath also published a work intitled Hydraulic Chymistry, in which he gives a particular account of all the processes for making such Extracts of the chief mineral, vegetable, and animal substances, as are most frequently used in the practice of Physic. His way of evaporating, by a gentle heat, the liquor containing the Extract of a triturated substance is a very good one: for we know that heat, if but a very little too strong, is capable of changing the natures of compound bodies, by disuniting their principles, and exhaling some of them.

If all vegetable matters were fat and succulent, as most pot-herbs are, triture would not be necessary for the making an Extract of them, even without the help of fire. We should have nothing to do, for that purpose, but to express their juices, as before, clarify them, and evaporate with a gentle heat
to

to the consistence of an Extract. But many vegetable substances, such as woods, barks, roots, &c. are dry, hard, and compact. These matters will not give out their Extract, without such an application of water as shall dissolve their saline, saponaceous, and mucilaginous parts. Now this must be effected either by triture, or by fire. Trituration has the advantage of procuring Extracts, in which the principles are perfectly unaltered, and retain the same proportions, with respect to each other, as in the plant: but then it is attended with the inconveniences of being very tedious, troublesome, and chargeable. When we come to deliver the methods of making Extracts by decoction and by infusion, we shall see what are the advantages and disadvantages of preparing Extracts by heat.

The matters, from which an Extract is to be made by triture, must be previously bruised and reduced into small parts, in order to facilitate the action of water upon them. The several filtrations and decantations here directed are intended to separate the grosser parts of the plant, that were only suspended in the liquor, but not truly dissolved, by means of the agitation and motion: for this reason also, the longer the liquor is left to settle, the purer will the Extract be.

Though the plant be triturated the first time with a great deal of water, and for a good while too, yet it is not by that means wholly exhausted: M. de la Garaye therefore directs the remainder to be triturated again with fresh water: but this second operation requires only half the water used in the former, and need be continued only half the time; the plant having been already opened by the former triture, and having fewer parts to give out. It is better to add fresh water, and triturate a second time, than to triturate but once, and for a greater length of time: for when the water is impregnated

with the principles of the plant to a certain degree, it is less capable of acting, and of dissolving more, than when it is pure.

As the water impregnated with the principles of the plant by triture must be almost wholly evaporated, in order to bring those principles nearer together, and that the whole may lie in the smallest compass possible; and moreover, as this evaporation must be effected by the gentlest heat, it is necessary to spread the liquor so, by distributing it among a great number of plates, that it shall be reduced in a manner entirely to surface. By this means the Extract may be evaporated even to dryness: and this is M. de la Garaye's practice. As the Extracts, thus evaporated to dryness, cannot be taken up otherwise than in little scales, the lower surfaces whereof, by adhering to the glazing of the plate, are smooth and shining, they in some measure resemble a crystallized Salt; which led M. de la Garaye into an error, and induced him to give the title of Essential Salts to the Extracts prepared in this manner. The Essential Salt is indeed contained in them: but still they are only Extracts, as Mr. Geoffroy hath shewn, in a Memoir on this subject given in by him to the Academy; since, besides the Essential Salt, they contain moreover, as was said before, a great deal of the oil and earth of the matters from which they were extracted. This, in the main, is no objection, but rather an advantage to them; considering that such saline Extracts are, on that account, so much the more like the substances from which they were obtained; especially with regard to their medicinal properties.

P R O C E S S II.

To extract from Seeds and Kernels, by Trituration, the Matter of Emulsions.

B LANCH the kernels of which you desire to make an Emulsion; put them into a marble mortar; add a very little water; and pound them with a wooden pestle. Continue pounding and triturating till the matter become like a white paste. From time to time pour on it, by little and little, more fair water warmed, still continuing the trituration; by which means the paste will grow thinner. Go on thus till every particle of your kernels be crushed to pap. Then add, still rubbing the mixture, enough of water to make the whole an actual fluid; and you will have a liquor of a dead-white colour, resembling milk. Strain it through a clean linen cloth: it will leave on the filter some coarse parts, which must be returned to those left in the mortar. Again triturate and rub the remainder of the kernels, with the addition of water as before. This second liquor will not be so white nor so rich as the former: filter it in the same manner, and again grind with water the solid parts remaining. In this manner proceed, repeatedly rubbing and adding fresh water, till it appear no longer milky, but come off clear. The white milky waters thus obtained go by the name of an *Emulsion*.

O B S E R V A T I O N S.

ALL the matters, from which a Fat Oil is obtainable by expression, produce Emulsions when triturated with water.

An Emulsion consists chiefly of two substances. One of these is mucilaginous, and soluble in water. This substance by itself would not give a milky appearance to the Emulsion, which, with it alone, would

be limpid. The other is a Fat Oil, which of itself is not soluble in water ; but being divided by the means of trituration into very small globules, it is dispersed through the whole liquor, and suspended therein by the aid of the mucilaginous part. It is this oily part that gives the Emulsion its dead-white, milky colour ; because it is not actually dissolved in the water, but only diffused through it.

If Oil be mixed with water in a phial, and the mixture strongly shaken for some time, with a rapid and continued motion, the Oil will be divided into a vast number of little globules, which intervening between the parts of the water will destroy its transparency, and give it a dead-white colour, like that of our Emulsion. But, as the Oil is not so minutely divided by this means, as by triturating the matters containing it ; and again, there being no mucilage in this liquor, as there is in Emulsions, the Oil soon separates from the water when it is left at rest, re-unites into round globules, and these joining together rise to the surface of the liquor, which then recovers its transparency.

The case is not exactly the same with Emulsions ; but something like it happens to them also. If they be left to stand quiet in a long bottle, the liquor, which at first appeared homogeneous, separates into two manifestly different parts. The upper part retains its dead-white colour, but is thicker and more opaque ; while the lower part becomes perfectly transparent. This is the beginning of an entire separation of the oily from the aqueous parts. The former, being the lighter, ascend and gain the upper part of the liquor ; while the lower, being freed from that which obstructed its translucence, recovers its proper limpidity : but the oily parts do not reunite into masses large enough to form one homogeneous whole, with the appearance and limpidness of Oil ; their being minutely divided and entangled

gled in the mucilage impeding their natural tendency.

Emulsions first begin to spoil, as they grow old, not by turning rancid and acrimonious like the Fat Oils drawn by expression, but by turning sour; which is owing to the great quantity of mucilage they contain. As there is a Fat Oil in their composition, they have the same virtues with that sort of Oil: but they are moreover incrassating, cooling, and emollient; qualities which render them extremely useful in acute and inflammatory disorders. They grow sour in a very short time, especially in the heat of summer; nay, they sometimes do so in two hours: and therefore they ought to be prepared from time to time as they are to be used.

The matter that is left when all the substance of the Emulsion is extracted, and from which the water comes off clear and limpid, is scarce any thing but the earthy part of the seed or kernel that was triturated; which, however, still retains a portion of tenacious and gross Oil, adhering to it so firmly as not to be separable by water.

The chyle and milk of animals resemble an Emulsion in several respects, and particularly in their dead-white colour; which arises, in the same manner, from the very minute particles of Oil contained in them, and distributed through an aqueous gelatinous fluid, but not dissolved therein. In general, whenever any Oil of any kind happens to be lodged in this manner between the parts of an aqueous liquor, it always makes the whole of an opaque white: for Oil will not mix with water, so as to produce a liquor that shall appear homogeneous and transparent, unless it be intimately dissolved in the water; which cannot be effected but by means of an union previously contracted between it and some saline matter; as is the case of mucilages, certain saponaceous matters, and some other com-

combinations of which we shall have occasion to treat in the sequel.

The methods we have hitherto proposed, for extracting from vegetable substances all that they will yield without the assistance of fire, are not capable of analyzing those substances accurately, as you may have observed ; since by expression and trituration we obtain only the liquid parts, impregnated indeed with almost all the principles of plants, which however are still combined with each other, and barely separated from the grossest earthy and oily parts. We must therefore necessarily have recourse to a more effectual expedient for carrying our analysis further. This expedient consists in making them undergo the action of fire, successively graduated, from the gentlest to the most violent heat.

But, before we enter on this Analysis of Vegetables, it is proper to describe the different operations that may be performed on Oils, the only pure principle we have been able to obtain without the help of fire. As we shall have occasion, when we come to treat of the analysis of plants by fire, to say a great deal more concerning Essential Oils, we reserve till then what relates to the operations that may be performed on them ; and confine ourselves here to the operations on Fat Oils,

C H A P. III.

OF OPERATIONS ON FAT OILS,

P R O C E S S I.

To attenuate Fat Oils, and change their nature, by exposing them to the action of fire, and distilling them.

MIX thoroughly three or four pounds of any Fat Oil whatever, with twice its weight of lime flaked in the air. Put this mixture into a large earthen retort, leaving a third part of it empty. Set it in a reverberating furnace, and lute on a receiver. Heat the vessel with a very gentle fire. A little phlegm will rise first, and will soon be followed by an Oil that will fall in drops from the nose of the retort. Continue the distillation very slowly, till you perceive the Oil that comes over begin to be not quite so fluid as before, but rather a little thicker.

Then unlute your receiver, and put another in its place. Continue the distillation, increasing your fire by degrees. The Oil that comes over will grow thicker and thicker, its fluidity will decrease, and it will acquire a dark-brown colour, which at last will become blackish. The Oil will then be very thick. Push the operation till nothing more will come off, though the retort be red-hot. During the whole time this distillation lasts, there rises a good deal of water, in company with the Oil. Keep the second thick Oil by itself.

Mix the Oil that came over first, in this operation, with an equal part of fresh lime flaked in the air.

Put the mixture into an earthen or glass retort, of a size so proportioned to the quantity, that a third part thereof may remain empty. Distill as before. The same phenomena will appear: a clear Oil will first come over, and be succeeded by one a little thicker. Then shift your receiver, and distill off all the rest of the Oil with an increased fire. The first Oil, obtained by this second distillation, will be clearer and thinner than that of the first distillation; and the second Oil will not be so thick, nor of so deep a colour as before.

Distill over again, in the same manner, the thin Oil of this second distillation, and go on thus repeatedly distilling, till the first clear Oil come over with a degree of heat not exceeding that of boiling water. Then, instead of mixing your Oil with lime, put it with some water into a glass retort, or into a body with its head fitted on, and distill it, keeping the water just in a simmer. Your Oil will be more and more attenuated, and, after being thus distilled twice or thrice with water, will be so limpid, so thin, and so clear, that you will scarce be able to distinguish it from water itself.

OBSERVATIONS.

FAT Oils, which are naturally mild, unctuous, inodorous, or have at most a scarce perceptible smell, resembling that of the fruit or kernel from which they were extracted, change their natures totally when exposed to the action of fire. If they be but heated so as to boil, they become acrid, lose much of their unctuousity, and acquire a very pungent odour. From several analogies, and by several experiments, recited in a Memoir on Oils which I read to the Academy, I shewed that these alterations of Fat Oils are produced by the fire's extricating an Acid in them, which before lay concealed and inactive. What I advanced on this subject
may

may be seen in the Memoirs of the Academy for 1745, and in my Elements of the Theory of Chymistry. I shall take occasion to add something more, in my Observations on the following process, by which these Oils are combined with Acids. In this place I shall only examine what passes in the repeated distillations they are here made to undergo.

Fat Oils do not rise in distillation without a degree of heat greater than that of boiling water; and therefore they must be distilled in a sand-bath, or with a naked fire. We prefer the latter method, for reasons elsewhere assigned, and chiefly because the Operator is more master of his fire; it being absolutely necessary, in this operation, that he have it in his power to suppress it in an instant, when he finds it too strong: for, in such a case, it will impetuously raise the thin Oil mixed with the thick; nay, the whole will be burnt, as it were, to a coal, if a degree of fire ever so little too strong be kept up but for a few moments. When this accident happens, it is always predicted by a great quantity of white vapours ascending with impetuosity out of the retort, and by drops of Oil following each other very fast, that are scarce limpid at first, and soon become of a dark colour. All this may be prevented by distilling very slowly, and with great patience.

Fat Oils may be distilled and attenuated without any additament: but then the operation, which is tedious and troublesome enough, even when lime is used, as appears from our description of the process, would be much more so if the Oil were distilled alone, without the addition of any thing to divide it, spread it, and enlarge its surface.

Lime is one of the best additaments that can be employed on this occasion; not only because it procures the advantages just mentioned, but also by reason that, being an absorbent of fat matters, it

unites with the grosser parts of the Oil, retains them, and so allows the thinnest and lightest parts to be readily separated from the rest. By this means it greatly expedites the operation; and, the more of it is added, with respect to the Oil, the sooner is a considerable quantity of thin limpid Oil obtained: and this is the reason of our directing a double quantity of lime to be mixed with the Oil in the first distillation.

Lime slaked in the air is employed preferably to quick-lime; because it is naturally divided into a very fine powder, and capable of mixing perfectly with all sorts of matters.

The water that first appears in the distillation comes from the lime: it is part of the humidity which the lime had imbibed from the air. This water continues to rise with the Oil during the whole distillation, according as the degree of heat is increased: and, if the distillation be finished by keeping the retort red-hot, for some time after all is come over, the lime in it will have a greyish cast, and, when water is poured on it, grow almost as hot as quick-lime.

If you resolve to carry on these distillations of a Fat Oil, till it become as light as an Essential Oil, it is necessary to begin with a pretty large quantity thereof, as three or four pounds: for the quantity of the Oil is considerably lessened by every distillation; not only because the thickest and grossest part is separated from it every time; but also because a portion of the Oil remains so strongly united with the lime, that the force of fire is not able to separate them. Moreover, there is reason to believe that some of it is decomposed every time it is distilled.

If Oil be distilled by itself, the thickest and heaviest part remains charred, as it were, in the retort, the inside of which is lined with a crust of coal,
that

that is to the last degree fixed: this therefore always occasions a diminution of the Oil.

A Fat Oil must be distilled eight or nine times, even with lime, before it become as light as an Essential Oil, and capable of rising wholly with the heat of boiling water: by that time therefore it must be considerably diminished; and if, at least, the quantity prescribed be not taken at first, there will scarce remain a few ounces capable of being distilled with water.

The portion of thick heavy Oil, obtained in the several distillations, may, if you will, be rectified again. For this purpose you must mix it with fresh lime, and distill it as you did the clear Oil. A portion of this also will be attenuated, and come over first. Thus all the Fat Oil may be subtilized by the action of fire; an absolutely charred black part excepted, that remains fixed, and appears susceptible of no change, but by burning it in the open air, and thereby reducing it to ashes, from which a little Fixed Alkali may be obtained. In this fixed part of the Oil the acid and earthy parts are combined therewith, in a greater proportion than they ought to be in pure Oil.

The portion of Oil that hath become light and thin is nothing but the purest oily part, separated from the gross Acids, and from a certain quantity of earth, which made it thick and heavy. This Oil resembles the Essential Oils in lightness, fluidity, and a penetrating agreeable odour: it dissolves in Spirit of Wine. We shall have occasion in the sequel to enlarge further on the qualities of the several sorts of Oils, and their solubility in Spirit of Wine, when we come to treat of Ardent Spirits and of Æther.

PROCESS II.

To combine Fat Oils with Acids. The decomposition of this combination.

PUT any Fat Oil whatever into a glass basin, and set it in a sand-bath very moderately heated. Pour on this Oil an equal quantity of concentrated Oil of Vitriol, which will immediately dissolve it with violence; a considerable ebullition and effervescence will arise, attended with great heat, and a prodigious quantity of black, thick vapours, in which may be easily perceived the smell of burnt Oil, together with that of a Sulphureous Acid. The mixture will become of a deep-red, black, and thick. Stir it with a small stick, till you observe that all is quiet.

OBSERVATIONS.

THE Vitriolic and Nitrous Acids unite with Fat Oils, and dissolve them with violence; but these Acids must be sufficiently strong and concentrated, otherwise they will not act upon the Oils. The Vitriolic Acid, in particular, dissolves them pretty thoroughly. If hot water be poured on the mixture described in our process, this water will become cloudy and milky, by dissolving some of it: so that Oils may be rendered soluble in water by the means of Acids. Spirit of Wine, which doth not attack Fat Oils in their natural state, unites perfectly with them, and makes a clear limpid solution of them, when they are thus combined with Acids.

The Acids also suffer a considerable alteration by contracting an union with Oils. They become much milder, and lose almost all their strength. If the mixture described in the process be distilled, there will come over a great quantity of an empyreumatic

reumatic acidulated phlegm, that smells strong of Sulphureous Spirit; an Oil thinner than the original saponaceous mixture; a weak oily Acid, and a very thick, black Oil. If the fire be made very strong, when the Oil ceases to rise, it sometimes happens that a little Sulphur sublimes into the neck of the retort.

By this analysis it appears that the strong concentrated Acid, which was an ingredient in the combination, is not now to be found. The Vitriolic Acid hath changed its nature, and is considerably weakened by the union it hath contracted with the principles of the Oil. The aqueous part of this latter substance weakens the other, and loads it with phlegm; the inflammable part thereof renders it sulphureous, and even converts it into Sulphur.

Hence it follows that some part of the Oil is decomposed, by the union it contracts with the Vitriolic Acid: for its phlogiston and its aqueous principle cannot be disunited, so as to form a Sulphureous Spirit, or an actual Sulphur, and an aqueous Acid, without the decomposition of a certain quantity of the Oil, in proportion to the two disjoined principles. Another portion of the Oil remains united with the Vitriolic Acid, without suffering any decomposition, and communicates to that portion of the Acid, with which it is so combined, a somewhat saponaceous quality, which makes it resemble the vegetable Acids.

Thus we see, that, when the Vitriolic Acid and a Fat Oil are combined together, they both suffer considerable changes; the Acid by the new alliances into which it enters, and the Oil by the decomposition it undergoes. In consequence hereof a much smaller quantity of Oil is obtained, by decomposing this combination, than was at first put in.

If the Oil abstracted by distillation be combined again with a fresh quantity of the concentrated Acid, the same effects will again follow; and by this means any quantity of Oil at pleasure may be entirely decomposed. This single experiment affords an evident proof of many important truths advanced in our Elements of the Theory.

Spirit of Nitre likewise dissolves expressed Oils. With Oil of Olives it forms a white paste, resembling a fine pomatum. This compound is perfectly soluble in Spirit of Wine. The Acid must be very strong and smoking to unite with this, or with any other Fat Oil: but it dissolves some of them with more rapidity than others; in which number is the Oil of Walnuts. It acts on these Oils with so much vehemence that it burns them, in some measure, making them black and thick.

PROCESS III.

To combine Fat Oils with Fixed Alkalis. Hard and Soft Soap. The decomposition of Soap.

TAKE a lixivium of Alicant kelp made more caustic by lime, as we shall shew when we come to speak of Alkalis. Evaporate this lye till it be capable of bearing a new-laid egg. Divide it into two parts; and to one of these put just water enough to weaken it so, that a new-laid egg will not swim in it, but fall to the bottom. With the lye thus weakened mix an equal quantity of fresh-drawn Olive Oil. Stir and agitate the mixture well, till it become very white. Set it over a gentle fire, and continue stirring it incessantly, that the two ingredients of which it is compounded may gradually combine together, as part of the water evaporates. When you perceive they begin to unite,

unite, pour into the mixture thrice as much of the first strong lye as you took of Olive Oil. Continue the coction with a gentle fire, always stirring the matter, till it become so thick that a drop of it fixes, as it cools, into the consistence that Soap ought to have. By dissolving a little of this Soap in water, you will discover whether or no it contains more Oil than ought to be in the composition. If it dissolve therein wholly and perfectly, without the appearance of the least little drop of Oil, floating on the water, it is a sign that it doth not contain too much Oil. If, on the contrary, you perceive any of these little globules, you must pour into the vessel, containing your matter, a little more of the strong lye, to absorb the redundant Oil. If there be too much of the Alkali, it may be discovered by the taste. If the Soap leave on your tongue the sensation of an Alkaline Salt, and produce an urinous savour, it is a sign that there is too much Salt in proportion to the Oil. In this case a little Oil must be added to the mixture, to saturate the super-abundant Alkali. An excess in the quantity of Alkali discovers itself likewise by the Soap's growing moist in the air, on being exposed to it for some time.

OBSERVATIONS.

FIXED Alkalis, even when resolved into a liquor, that is, when loaded with much water, unite easily with Fat Oils, as appears from the experiment just recited, and require but a moderate heat to perfect that union. This combination may even be completely effected without the aid of fire, and by the heat of the sun only, provided sufficient time be allowed for that purpose; as Mr. Geoffroy found upon trial. It only requires the mixture of the Oil and Alkali to be kept five or six days in digestion, and stirred from time to time. A lixivium of pure Alkali, not acuated by lime, may also be used to

make Soap: but it is observed that the combination succeeds better, and that the Alkali unites sooner and more perfectly with the Oil, when it is sharpened by lime.

The Oil is first mixed with a weaker and more aqueous lye, to the end that the combination may not take place too hastily, but that all the particles of the two substances to be compounded together may unite equally. But as soon as the Alkali begins to dissolve the Oil gradually and quietly, the dissolution may then be accelerated; and that is done by adding the remaining lye, which is stronger and less diluted than the other.

Soap made with Olive Oil is white, hard, and hath not a very disagreeable smell: but as that Oil is dear, others, even the fat and oils of animals, are sometimes substituted for it. The Soaps made with most of these other matters are neither so hard, nor so white, as that made of Olive Oil: they are called *Soft Soaps*.

Oils thus associated with Fixed Alkalis are by that means rendered soluble in water; because the Alkaline Salts, having a great affinity with water, communicate part thereof to the Oils with which they are now incorporated. Yet the Oil is not for all that rendered thoroughly miscible with water, or perfectly soluble therein; for the water in which Soap is dissolved hath always a milky cast: now there is no other criterion of a perfect solution but transparency.

Alkalis also lose part of their affinity with water, by the union they thus contract with Oils: for, when the combination is properly made, they no longer attract the moisture of the air, nor doth water dissolve them in such quantities as before. The composition of Soap is plainly a saturation of an Alkali with an Oil; and, in order to make perfect Soap, we are forced, as was said in the process, to grope,
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in a manner, by repeated trials, for this point of saturation; just as when we prepare a Neutral Salt by saturating an Alkali with an Acid. The union which the Oil contracts with the Alkali makes it lose, in part, the readiness with which it naturally takes fire; because the Salt is not inflammable: the water also, which enters, in pretty considerable quantities, into the composition of Soap, as we shall presently see, contributes a good deal to hinder the accension of the Oil.

Soap may be decomposed either by distilling it, or by mixing it with some substance that hath a greater affinity than Oil with Alkalis.

If we decompose it by distillation, a phlegm, or transparent spirit, of a somewhat yellowish colour, first comes over. This liquor is the aqueous part of the Soap, quickened by a little of its Alkali, which gives it an acrid taste. It is followed by a red Oil, which at first is pretty thin and limpid, but thickens as the distillation advances, grows black, and has a very disagreeable empyreumatic smell. This Oil is soluble in Spirit of Wine.

When the distillation is finished, that is, when the retort being kept red-hot for some time will discharge no more, there is left in it a saline mass; which is the Alkali of the Soap, crufted over with some of the most fixed parts of the Oil, that are charred to a coal. This Salt may be restored to the same degree of purity it had before its combination with the Oil, by calcining it in a crucible with a naked fire, that may consume this burnt part of the Oil, and reduce it to ashes.

It is plain that the Oil contained in Soap is affected by distillation, much in the same manner as that which we mixed with lime and distilled.

Mr. Geoffroy, by analysing Soap with care, discovered that two ounces thereof contain ninety-six grains of Salt of kelp, freed from all Oil and mois-

ture; or two drams and forty-eight grains of that Salt, as it is used in manufacturing Soap; that is, containing water enough to make it crystallize; one ounce three drams twenty grains of Olive Oil; and about two drams four grains of water.

As Acids have a greater affinity than any other substance with Alkalis, they may be very effectually employed to decompose Soap.

If you propose to decompose Soap by means thereof, you must first dissolve it in a sufficient quantity of water. Mr. Geoffroy, who made this experiment likewise, dissolved two ounces thereof in about three gallons of warm water, and to the solution added Oil of Vitriol, which he let fall into it drop by drop. Every time a drop of Acid falls into it, a *coagulum* is formed in the liquor. The vessel in which the solution is contained must then be shaken, that the Acid may equally attack all the Alkali diffused in it. When no new coagulation is produced by a drop of the Acid, it is a sign you have added enough. The liquor then begins to grow clear: and if another quart of water be added, in order to facilitate the separation of the oily particles, you will see them rise and unite together on the surface of the liquor.

This is a pure, clear, true Olive Oil, hath its taste, its smell, and, like it, is fluid in warm weather, and becomes fixed by cold. Yet it differs in some respects from that which never hath been united with an Alkali in order to form a Soap; for it burns more vividly and more rapidly, and is soluble in Spirit of Wine. We shall account for these differences when we come to treat of Ardent Spirits.

Not only the Vitriolic Acid, but all others, even those obtained from vegetables, are capable of decomposing Soap, and separating the Oil from the Alkali. In the liquor wherein Soap is thus decomposed is found a Neutral Salt, consisting of the
Acid

Acid made use of, united with the Alkali of the Soap. If the Vitriolic Acid be used, you will have a Glauber's Salt; a quadrangular Nitre, if the Nitrous Acid be used; and so of the rest.

The facility with which Acids decompose Soap is the reason that no water, but what is very pure, will dissolve it, or is fit to be used in washing with it.

Water that doth not dissolve Soap well is usually called *Hard Water*. Such waters contain a certain quantity of saline matters, washed out of the earths through which they pass. The hardness of water is generally occasioned by selenitic particles.

The hardness of all the well-water in and about Paris is owing to a considerable quantity of Selenitic Gypsum with which the soil abounds. The Selenites, we know, are Neutral Salts, consisting of the Vitriolic Acid united with an earthy basis. If therefore Soap be put into water in which a Salt of this kind is dissolved, it is evident that the Vitriolic Acid in the Selenites, having a greater affinity with the fixed Alkali of the Soap than with its own earthy basis, will quit the latter to unite with the former; and thus the Soap will be decomposed instead of being dissolved. Accordingly we see, that when we attempt to dissolve Soap in our well-water, the surface of the liquor is in a short time covered with a fat oily pellicle. However, this decomposition of Soap is not complete; at least but a small part of it is perfectly decomposed; because the great quantity of Selenites, with which the water is impregnated, hinders the Soap from mixing so thoroughly with it, as is requisite to produce a total decomposition thereof.

All mineral waters are likewise hard, with regard to Soap; for as most of them owe their virtues to the efflorescences they have washed off, from pyrites that have grown hot and begun to be decomposed,

they are impregnated with the saline matters produced by pyrites in that state: that is, with aluminous, vitriolic, and sulphureous substances, which have the same effect on Soap as the Selenites have.

Mineral waters containing Neutral Salts only, such as Sea-Salt, Epsom-Salt, Glauber's Salt, are nevertheless hard with regard to Soap, though the Acids of those Salts, being united with Fixed Alkalis, are incapable of decomposing it. The reason is, that those Neutral Salts are more soluble in water than Soap is; so much indeed as even to exclude it: because each of the two principles that composed them hath a very great affinity with water; whereas only one of the principles of Soap, namely its Alkali, hath that affinity; the other, to wit, the oily principle, having none at all. Thus water impregnated with an Acid, or with any Neutral Salt, is hard with regard to Soap, and incapable of dissolving it; and hence it follows that Soap is a sort of touchstone for trying the purity of water.

Wine dissolves Soap; but imperfectly, because it contains an acid or tartarous part. Spirit of Wine also dissolves it: but neither is this dissolution perfect; because it contains too little water: for its spirituous part can dissolve nothing but the Oil of the Soap; and the Alkali is not at all, or at least in a very small quantity, soluble in this menstruum. The true solvent of Soap is therefore a liquor that is partly spirituous, partly aqueous, and not acid.

Brandy has these qualities: and accordingly it is the solvent that unites best with Soap, dissolves the greatest quantity, and makes the most limpid solution thereof. Yet even this solution hath something of a milky cast, occasioned by its not being entirely free from an acid, or the tartarous principle. This fault may be easily corrected, by mixing with it a little Alkali to absorb the Acid. A dram of crystallized salt of kelp mixed with three ounces and a
half

half of good brandy, renders it capable of dissolving an ounce and two drams of good hard Soap, into a perfectly limpid liquor. This experiment also we owe to Mr. Geoffroy.

Some years ago it was discovered that Soap might be used with great success in Medicine, and that it possesses the property of dissolving the stony concretions that form in several parts of the body, particularly in the kidneys and bladder. Soap is the basis of the composition known by the name of *Mrs. Stephens's Remedy*; and in this one ingredient its whole virtue resides.

From what hath been said on the nature of this compound, as well as on the cause and phenomena of its dissolution, it plainly appears to be of the last consequence, in administering it to a patient, that his constitution be considered, and a proper regimen ordered. All Acids should be absolutely forbid him; as we know they hinder the Soap from dissolving, and decompound it; and if the patient have any acidities in the first passages, matters capable of neutralizing them should be prescribed him; as prepared crabs eyes, and other absorbents known in Medicine: In such cases those with which the Soap is compounded in *Mrs. Stephens's remedy* may be of use.

P R O C E S S IV.

To combine Fat Oils with Sulphur.

PUT any Fat Oil whatever into an earthen vessel; add to it about the fourth part of its weight of Flower of Sulphur, and set the vessel in a furnace, with lighted coals under it. When the Oil hath acquired a certain degree of heat, the Sulphur will melt, and you will see it fall immediately to the

bottom of the Oil, in the form of a very red fluid. The two substances will remain thus separated, without mixing together, while the heat is no greater than is necessary to keep the Sulphur in fusion. Increase it therefore; but slowly and with circumspection, lest the matter take fire. When the Oil begins to smoke, the two liquors will begin to mix and look turbid: at last they will unite so as to appear one homogeneous whole. If you keep up the heat so that the mixture shall always continue smoking and ready to boil, you may add more Sulphur, which will perfectly incorporate with it: and thus may a pretty considerable quantity thereof be introduced into this composition.

OBSERVATIONS.

THE Phlogiston and the Vitriolic Acid have each an affinity with Oils. It is not therefore surprising that Sulphur, which is a compound of these two substances, should be soluble in oily matters. Yet it is remarkable that Essential Oils, which are much thinner than the Fat Oils, dissolve Sulphur with much more difficulty; as will be shewn when we come to treat of those Oils; and that Spirit of Wine, which contains an exceeding subtile Oil, doth not act upon Sulphur at all.

Oil, by contracting an union with Sulphur, produces a considerable alteration in that mineral: a phenomenon so much the more surprising, that we know it to be, in some sort, unalterable by any other solvent, of what kind soever, add that its nature admits of no change but by burning. We shall say more on this subject under the head of Essential Oils.

PROCESS V.

To combine Fat Oils with Lead, and the Calxes of Lead. The Basis of Plasters. The Decomposition of this Combination.

INTO an earthen vessel put granulated Lead, Litharge, Ceruse, or Minium; and pour thereon twice its weight of any Fat Oil whatever. If you set the vessel over a brisk fire, the Lead at bottom will melt before the Oil begin to boil. When it boils, stir the matter with a stick: the Lead or the Calx of Lead will gradually disappear, and at last be totally dissolved by the Oil, to which it will give a very thick consistence.

OBSERVATIONS.

FAT Oils dissolve not only Lead, but its calxes also: nay, they dissolve the latter more readily than Lead in substance; probably because they are more divided. The result of a combination of these matters is a thick tenacious mass, that grows in some degree hard in the cold, and soft by heat. This composition is known in Pharmacy by the name of *Plaster*. It is made up with several drugs into plasters, which partake of the virtues of those drugs; so that it is the basis of almost all plasters.

Lead itself is seldom used to make plasters: Ceruse, Litharge, or Minium are preferred to it; because these matters unite, as hath been said, more readily and more easily with Oils.

It sometimes happens that the Oil is burnt in the operation, and that the calx of Lead is partly resuscitated: and this gives the plaster a black colour, which however it ought not to have. This accident is occasioned by an excess of heat: and as it is very difficult to keep the Oil and the Lead in the

the proper degree of heat, seeing both these matters are apt to grow very hot, it hath been contrived to put into the vessel, in which the coction is to be performed, a pretty large quantity of water; which being susceptible only of a much smaller and a certain degree of heat, that is constantly the same when it boils, procures the advantage of having the composition very uniform, and very white.

It is necessary to stir the mixture incessantly, in order to prevent the burning of the combined Oil and Lead; which, as they unite, sink in the water by their greater weight. If the water happen to be wasted before the Oil hath dissolved all the Lead, or before the plaster hath acquired a proper degree of consistence, you must remove the vessel from the fire, and let the mixture cool, before you add more: for, if this precaution be neglected, the heat of the matter, which is now much greater than that of boiling water, will occasion a considerable explosion and extravasation thereof, though the water poured into it be as hot as possible.

The combination of Fat Oil with a Calx of Lead may be considered as a sort of metallic Soap, having a metalline Calx, instead of a Fixed Alkali, for its basis. Mr. Geoffroy hath observed, that if a pound of Litharge, rubbed very fine and well washed, be incorporated with two pounds of Olive Oil, in the same manner as plaster is made, keeping water enough in the vessel to hinder the mixture from burning, there rises a smoke, while the Oil is uniting with the Calx of Lead, smelling much like that which rises from Soap.

The Oil may be separated from the Calx of Lead, by the methods used to separate it from a Fixed Alkali: and when it is so separated, it hath the same properties as that separated from common Soap.

This species of metallic Soap, formed by the union of a Fat Oil with the Calx of Lead, is not
solu,

soluble in water, and communicates nothing to it but a greasy taste. Therefore, if you would decompose it by the means of an Acid, you must pour that Acid immediately on the compound. The Acid will attack and dissolve the Calx of Lead; and the Oil, being thus set at liberty, will rise clear and limpid to the surface of the acid liquor. Distilled vinegar effects this separation better than any other Acid, because it is the true solvent of Lead.

CHAP. IV.

OF THE SUBSTANCES OBTAINED FROM VEGETABLES WITH A DEGREE OF HEAT NOT EXCEEDING THAT OF BOILING WATER.

PROCESS I.

To obtain from Plants, by distilling them with the mean degree of heat between freezing and boiling water, a liquor impregnated with their Principle of Odour.

IN the morning, before sun-rise, gather the plant from which you design to extract its odoriferous water. Chuse the plant in its full vigour, perfectly sound, and free from all adventitious matters, except dew. Put this plant, without squeezing it, into the body of a tinned copper alembic, and set it in a water-bath. Fit on its head, and to the nose thereof lute a glass receiver with wet bladder.

Warm the bath to the mean degree between freezing and boiling water. You will see a liquor distill and fall drop by drop into the receiver. Continue the distillation with this degree of heat, till no more drops

drops fall from the nose of the alembic. Then unlute the vessels; and if you have not as much liquor as you want, take out of the cucurbit the plant already distilled, and put a fresh one in its place. Distill as before, and go on thus till you have a sufficient quantity of odoriferous liquor. Put it into a bottle; stop it close; and set it in a cool place.

OBSERVATIONS.

THE liquor obtained from plants, with the degree of heat here prescribed, consists of the dew that was on the plant, and some of the phlegm of the plant itself, together with its odorous principle. Mr. Boerhaave, who examined this odoriferous part of plants with great care, calls it the *Spiritus Rector*. The nature of this Spirit is not yet thoroughly ascertained; because it is so very volatile, that it cannot easily be subjected to the experiments that are necessary to analyze it, and to discover all its properties. If the bottle containing the liquor, which may be considered as the vehicle of this Spirit, be not exceeding carefully stopped, it flies quite off: so that in a few days nothing will be found but an insipid inodorous water.

Great part of the virtue of plants resides in this their principle of odour; and to it must be ascribed the most singular and the most wonderful effects we every day see produced by them. Every body knows that a great number of odorous plants affect, in a particular manner, by their scent only, the brain and the *genus nervosum*, of such especially whose nerves are very sensible, and susceptible of the slightest impression; such as hypochondriacal or melancholy men, and hysterical women. The smell of the Tuberoſe, for instance, is capable of throwing such persons into fits, so as to make them drop down and swoon away. The smell of Rue again, which is
equally

equally strong and penetrating, but of a different kind, is a specific remedy against the ill effects of the Tuberoſe; and brings thoſe perſons to life again, with as quick and as ſurpriſing an efficacy, as that by which they were reduced to a ſtate not unlike death. This is Mr. Boerhaave's obſervation.

The odorous exhalations of plants muſt be conſidered as a continual emanation of their *Spiritus Reſtor*: but as growing plants are in a condition to repair, every inſtant, the loſſes they ſuſtain by this means, as well as by tranſpiration, it is not ſurpriſing that they are not ſoon exhausted, while they continue in vigour. Thoſe, on the contrary, which we diſtill, having no ſuch reſource, are very ſoon entirely deprived of this principle.

The ſeparation of the *Spiritus Reſtor* from plants requires but a very gentle heat, equally diſtant from the freezing point, and from the heat of boiling water. Accordingly the heat of the ſun in ſummer is ſufficient to diſſipate it almoſt intirely. This ſhews why it is dangerous to ſtay long in fields, or woods, where many noxious plants grow. The virtues of plants reſiding chiefly in their exhalations, which the heat of the ſun increaſes conſiderably, a ſort of atmosphere is formed, round them, and carried by the air and the wind to very great diſtances.

For the ſame reaſon the air of a country may be rendered ſalutary and medicinal, by the exhalations of wholeſome plants growing therein. From the facility with which the odorous principle of plants evaporates, we learn what care ought to be taken in drying thoſe intended for medical uſes, ſo as to preſerve their virtues. They muſt by no means be expoſed to the ſun, or laid in a warm place: a cool, dry place, into which the rays of the ſun never penetrate, is the propereſt for drying plants, with as little loſs of their virtue as poſſible.

Though there is reason to believe that every vegetable matter hath a *Spiritus Rectior*, seeing each hath its particular scent, yet this principle is not very perceptible in any but those which have a very manifest odour: and accordingly it is extracted chiefly from aromatic plants, or the most odoriferous parts of plants. I say the most odoriferous parts; because, in most plants and trees, there are generally certain parts, that have a much more sensible, and much stronger scent than the rest. The odour of a plant, or of a tree, hath its principal residence sometimes in the root, sometimes in the leaves, at other times in the bark or wood, and very frequently in the flowers and seeds. Therefore, when you design to extract the principle of odour from a vegetable that is not equally odoriferous in every part, you must chuse those parts that have the most perceptible and strongest scent.

PROCESS II.

To extract the Fat Oils of Plants by Decoction in boiling Water. Cacao-Butter.

POUND or bruise in a marble mortar your vegetable substances, abounding with the Fat Oil which you intend to extract by decoction: tie them up in a linen cloth: put this packet into a pan, with seven or eight times as much water, and make the water boil. The Oil will be separated by the ebullition, and float on the surface of the water. Skim it off carefully with a ladle, and continue boiling till no more Oil appear.

OBSERVATIONS.

THE heat of boiling water is capable of separating the Fat Oils from vegetable matters that contain

tain any: but this is to be effected by actual decoction only, and not by distillation; because these Oils will not rise in an alembic with the heat of boiling water. We are therefore necessitated to collect them from the surface of the water, as above directed. By this means a much greater quantity of Fat Oil may be obtained than by expression alone; because the degree of heat applied greatly facilitates the separation of the Oil. For a convincing proof of this truth, take the remains of any vegetable matters, from which the Oil hath been so thoroughly expressed that they would yield no more; boil them in this manner, and you will obtain a great deal more Oil.

The water used in this coction generally becomes milky, like an emulsion; because it contains many oily particles, that are dispersed in it just as in an emulsion. Nevertheless this way of obtaining the Fat Oils is not generally practised, because the heat, to which they are exposed in the operation, occasions their being less mild than they naturally are: but it is an excellent method, and indeed the only one that can be employed, for extracting from particular vegetables certain concrete oily matters, in the form of Butter or Wax; which matters are no other than Fat Oils in a fixed state. The Cacao yields, by this means, a very mild Butter; and in the same manner is a Wax obtained from a certain shrub in America.

The heat of boiling water melts these oily matters, which then ascend to the surface of the liquor, and float on it like other Oils. They afterwards fix as they cool, and resume their natural consistence. We shall see in the sequel that they cannot be extracted in a concrete form by distillation, which requires a greater degree of heat than that of boiling water; because distillation changes their nature, partly decomposes them, and prevents their returning to their proper consistence as they cool.

PROCESS III.

To extract the Essential Oils of Plants by distillation with the heat of boiling water. Distilled waters.

PUT into a cucurbit the plant from which you design to extract the Essential Oil. Add as much water as will fill two thirds of your vessel, and dissolve therein half an ounce of Sea-salt for every quart of water you use. To this body fit on an alembic-head, and to the nose thereof lute a receiver, with sized paper, or wet bladder. Set it in a furnace, and let the whole digest together, in a very gentle warmth, for twenty-four hours.

This being done, light a wood fire under your vessel, brisk enough to make the water in it boil immediately. Then slacken your fire, and leave it just strong enough to keep the water simmering. There will come over into the receiver a liquor of a whitish colour, somewhat milky; on the surface of which, or at the bottom, will be found an Oil, which is the Essential Oil of the Vegetable you put into the cucurbit. Continue your distillation with the same degree of heat, till you perceive the liquor come off clear, and unaccompanied with any Oil.

When the distillation is finished, unlute the receiver; and, if the Essential Oil be of that sort that is lighter than water, fill the vessel up to the top with water. On this occasion a long-necked matraass should be used for a receiver; that the Oil which floats on the water may collect together in its neck, and rise up to its mouth. Then in the neck of this vessel put the end of a thread of cotton-twine, so that the depending part without the vessel may be longer than that in the Oil, and the extremity thereof hang within the mouth of a little phial, just big enough to contain your quantity of Oil. The Oil will rise along the yarn as in a siphon, filter through

it, and fall drop by drop into the little phial. When all the Oil is thus come over, stop your little bottle very close, with a cork coated over with a mixture of wax and a little pitch.

If your Oil be ponderous, and of the sort that sinks in water, pour the whole contents of the receiver into a glass funnel, the pipe of which must terminate in a very small aperture that may be stopped with your fore-finger. All the Oil will be collected in the lower part of the funnel: then remove your finger, and let the Oil run out into a little bottle through another small funnel. When you see the water ready to come, stop the pipe of the funnel, and cork the bottle containing your Oil.

OBSERVATIONS.

ESSENTIAL Oils, though they all resemble each other in their principal properties, are nevertheless very different in some respects: for which reason almost every one of them requires a particular management, for obtaining it with the greatest advantage possible, both as to quality and quantity.

One of the first things requisite is, to chuse the proper time for distilling the plant, from which you desire to extract the Essential Oil; because the quantity of Oil varies considerably, according to the season of the year, as well as the age of the plant. For example, the most favourable time for obtaining these Oils from the leaves of ever-green plants or trees, such as Thyme, Sage, Rosemary, the Orange, the Bay, the Fir, &c. is the end of autumn; because these vegetables contain a great deal more Oil at that season than at any other. With regard to annual plants, they must be chosen when in their prime, and just before they begin to decline. The time therefore of gathering them is when they begin to flower: and if you want to extract the Oil

from the flowers themselves, you must pull them just when they are newly blown.

Secondly, it must be observed that the Essential Oils of plants are, as it were, the chief residence and reservoir of their odorous principle; that they are to be found wherever that principle exists, and never where it is not: so that what we said concerning the *Spiritus Rector* of plants is applicable here. It must be remembered that all the parts of some vegetables are odoriferous. Such plants may be put into the alembic all together, and the Essential Oil distilled from all their parts at once. But others, and indeed the greatest number, have no odour, or at least none that is very perceptible, except in some particular parts; as in their leaves, flowers, roots, or seeds: therefore, when you want to have the Essential Oil of such a plant, you must chuse that part in which the odour resides. The sense of smelling must be the Artist's principal guide on this occasion.

Thirdly; all vegetables, and all the parts of vegetables, have not the same texture: some are hard and compact, as woods, barks, and some roots; others are tender and succulent, as most annual plants, and some fruits. For this reason they must be differently prepared for distillation. It may be laid down as a general rule, that, the closer and more compact their texture is, the more they require to be opened and divided, either by comminuting them into small particles, or by digesting them a considerable time in water acuated with Salt.

Fourthly; though all Essential Oils be capable of rising in distillation with the heat of boiling water, yet they have not all an equal degree of levity and weight: on the contrary, they vary exceedingly in this respect: some, as for instance those of all our European aromatics, being lighter than water, so that they always float on its surface; whereas others,
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such as those of Cloves, Sassafras, &c. which are Indian aromatics, are heavier than water, and always sink in it by their specific gravity. These differences therefore require different methods of distillation. It is proper, for example, to make use of a low alembic in distilling such Essential Oils as are heavier than water; and moreover, to facilitate their separation, by applying a degree of heat somewhat stronger than that of boiling water. This is easily done by impregnating the water with a proper quantity of Sea-salt, or the Vitriolic Acid; for, the more saline matters are contained in water, the more will the degree of heat it acquires, by being brought to boil, exceed that of pure boiling water.

Fifthly; Essential Oils differ from one another in point of fluidity. Some are as thin and as fluid as Spirit of Wine: of this number is the Essential Oil of Turpentine. Others again are thick, and even congeal as they cool: such, for instance, is the Oil of Roses. In distilling Oils of this latter sort, care must be taken that the spout of the alembic head do not grow too cold, but be kept always in such a degree of warmth, as may prevent the Oil from fixing in it, and stopping it up; which would interrupt the distillation, and might also occasion some other more considerable inconveniences, of which we shall take notice presently.

From what hath been said it appears that the distillation of Essential Oils cannot be regulated by any one general rule; but that the manner of operating must be a little varied, according to the nature of the Oil to be distilled, and to that of the vegetable from which it is to be drawn.

The time of day, fittest to gather plants for this distillation, is the morning before sun-rise; because the coolness of the night hath shut all their pores, and concentrated their odour: whereas in the evening, after the plants have been exposed all day to

the heat of the sun, their odorous principle is in a great measure dissipated, and they are left almost quite exhausted of it. Now, the more of the odorous principle the plants contain, the more Essential Oil will they yield, and the more virtue will that Oil have.

Plants fresh gathered, and as yet full of moisture, do not yield so much Oil in distillation as they do when dried; because the oily particles in a very moist plant are more diffused, and even separated from each other, by the interposition of the aqueous parts: whence it comes to pass that, in distillation, they ascend in a state of separation from each other; so that being dispersed through the water they give it a milky colour, like that of an emulsion; and cannot unite together but in small quantities, which hinders their being easily separated from the water.

This inconvenience doth not happen, or at least is considerably less, when the greatest part of the humidity of the plant is evaporated by desiccation: for the oily particles, being thus delivered from the intervening aqueous parts, which kept them separated from each other, are brought nearer together, unite, and form little visible globules of Oil, which easily emerge from the water employed in the distillation. But, in drying plants from which the Essential Oil is to be extracted, great care must be taken that they be neither exposed to the sun, nor laid in a warm place; because the heat would carry off part of their odour, and even, from some plants, a pretty considerable quantity of their Essential Oil.

Plants of a loose texture, that easily give out their Essential Oils, need not be comminuted, or macerated in water with Salt. But this method must unavoidably be taken with such as are hard, and do not readily part with their Oil. Woods, barks, roots, for instance, must be first rasped, then

then set to macerate in water impregnated with Salt, as before directed; and this sometimes for several weeks before they be distilled.

On this occasion Salt procures three different advantages. In the first place, it prevents the matters, that must stand in maceration for some time, from running into fermentation: an inconvenience that would considerably diminish the quantity of Essential Oil, or perhaps rob us of the whole, by converting it into an Ardent Spirit, if the fermentation were spirituous; or into a Volatile Alkali, if it went on to the last stage, and as far as putrefaction. In the next place, it acuates the water, and renders it more capable of penetrating and properly dividing, during the maceration, the texture of the plant which requires to be thus prepared. Lastly, it adds a little to the heat of the boiling water, and so promotes the ascent of the heaviest Oils.

Nevertheless, when you find it necessary, for the reasons assigned above, to mix Salt with the water to be employed in distilling your Essential Oil, you must be cautious of putting in too much. You will indeed obtain, by means thereof, much more Oil than if you distilled it without Salt: but, as a great quantity of Salt will make the water acquire a much greater degree of heat, than that of pure boiling water, a good deal of the heavy Oil of the vegetable will be raised by such a heat, mix with the Essential Oil, deprave it, and make it like those that are adulterated with a mixture of some heterogeneous Oil, as will be afterwards shewn.

When every thing is prepared for distillation, it is proper, as directed in the process, to apply at once a flaming fire, brisk enough to make the liquor boil immediately: for, if the water be kept long heating before it be made to boil, the Essential Oil, which cannot rise without the heat of boiling water, will, by a less degree of heat, be only agitated, dashed

about every way, and churned as it were ; by which means it will be divided into very minute particles, and dispersed in the water, which will thence acquire a milky colour : and consequently we shall fall into the inconvenience that was pointed out above, as happening when we distill plants without having dried them, and while they are loaded with all the moisture and sap that was in them when fresh gathered.

When the water in the cucurbit boils, it will be known by the noise that boiling water usually makes, which is produced by the numerous bubbles that rise and burst on its surface. The spout of the alembic is then so hot, that a man cannot lay his finger on it, without such a sensation of burning heat as is not to be endured. With this degree of heat the water distills in drops, which succeed each other so fast, that they seem to form a continued small stream ; and this water is replete with much Essential Oil.

And now it is proper to weaken the fire considerably, so as to leave it but just strong enough to keep the liquor gently boiling : for if the distillation be urged too precipitately, the aqueous and oily vapours, being forcibly hurried up by too great a heat, may carry along with them some parts of the plant, which may stick in the spout, stop it up, and endanger the bursting of the vessel, or at least the forcing off its head, by the exceedingly rarefied particles of water, oil, and air, all striving to escape at the same time ; and these burning hot vapours, being discharged with impetuosity, may not only scald the Operator, but injure his lungs.

In such distillations it is of consequence to keep constantly cooling the head of the alembic, by frequently renewing the water in the refrigeratory, in order to facilitate the condensation of the oily particles.

cles. The water in the cooler ought to be renewed when it begins to smoke very perceptibly.

Whatever care be taken to save as much of the Oil as possible, and to prevent its being left dispersed in the water, yet some loss of this kind cannot be totally avoided: and thus the water that rises in distilling the Oil is always more or less milky, and strongly scented, even after it is separated from the Essential Oil. Yet this portion of the Oil and of the odorous principle, which is retained by the water employed in such distillation, is not therefore lost: the water impregnated with these principles partakes of the properties of the plant from which the Essential Oil was drawn, and may be used medicinally: it is known in Pharmacy by the title of the *Distilled Water* of the plant.

The same water may be used again, with advantage, in distilling the Essential Oil of a fresh plant of the same sort; because the oily and odorous particles, with which it is impregnated, joining with those afforded by the fresh plant, form larger *molecule*, capable of uniting more easily, and emerging better from the water; and consequently they increase the quantity of Oil. Thus the same water may be always employed in new distillations; and, the oftener it is used, with the greater advantage may it be used again.

After all the Essential Oil is risen, if the distillation be continued, and the receiver changed, the liquor that will then come off will not be milky, but limpid. It will have no odour at all of the plant, but a kind of sourish smell; and indeed it is a part of the Acid of the vegetable in the still, which is elevated by the heat of boiling water, after all the Essential Oil is come over.

If you intend to keep the distilled water which hath served as a vehicle to the Essential Oil, and design it for medicinal use, great care must be taken

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to stop the distillation before this acid phlegm begin to rise: for, if it should mix with the distilled water, it would spoil it, and hinder it from keeping; probably because it contains some mucilaginous parts, which are apt to putrify.

P R O C E S S IV.

To extract the Essential Oils of Plants by distillation per descensum.

REDUCE to a powder, or a paste, the vegetable substances from which you intend to extract the Essential Oil by the method proposed. Lay this matter about half an inch thick on a fine, close, linen cloth. If it be dry and hard, expose the cloth containing it to the steam of boiling water, till the matter become moist and soft. Then lay the cloth, with its contents, over the mouth of a very tall cylindrical glass vessel, which is to do the office of a receiver in this distillation; and, by means of a piece of small pack-thread, fasten down the extremities of the cloth, by winding the thread several times over them and round the vessel; in such a manner, however, that the cloth be not tight, but may yield to a small weight, and sink about five or six lines deep into the vessel over which it is fastened. Set this recipient in a larger vessel, containing so much cold water as will reach half way up the cylindrical vessel; which, having little in it but air, must be ballasted with as much lead as will sink it to the bottom of the water.

On the cloth containing the substance to be distilled set a flat pan of iron or copper, about five or six lines deep, that may just fit the mouth of the glass vessel, over which the cloth is fastened, so as to shut it quite close. Fill this pan with hot ashes, and on these lay some live coals. Soon after this
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you will see vapours descend from the cloth, which will fill the recipient, and drops of liquor will be formed on the underside of the cloth, from whence they will fall into the vessel. Keep up an equal gentle heat, till you perceive nothing more discharged. Then uncover the recipient: you will find in it two distinct liquors; one of which is the phlegm, and the other the Essential Oil of the substance distilled.

OBSERVATIONS.

THE apparatus for distilling above described is very convenient, when we have not the vessels necessary for distilling with water, or when we want to obtain the Essential Oil of any vegetable substance in much less time. The aqueous and oily parts of the substances distilled in this manner, being rarefied by the heat of the fire placed over them, cannot ascend upwards, because they are close confined on that side; and moreover, the fire which rarefies them possessing all the upper part of the vessel in which they are contained, they are forced to fly from it to the place which most favours their condensation: and this determines them to descend in the recipient, where they meet with a coolness that condenses and fixes them. It was with a view to promote this condensation, that we ordered the lower part of the recipient to be sunk in cold water.

Cloves are one of those substances whose Essential Oil is best obtained by this method. In the same way also may be drawn the Essential Oil of Lemon-peel, Citron-peel, Orange-peel, Nutmegs, and several other vegetable substances: but you must be cautious of applying too strong a heat; for in that case the Oil, instead of being white and limpid, acquires a red, dark-brown, blackish colour, is burnt, and smells of empyreuma: and, on the other hand, if you do not apply a proper degree of heat,

heat, you will scarce get any Oil at all. It is the surest, and therefore the best, way to distill these Oils with water in an alembic. And indeed the distillation *per descensum* is seldom used, but out of curiosity to try its effect, or on such pressing occasions as allow no choice.

PROCESS V.

Infusions, Decoctions, and Extracts of Plants.

MAKE some water boiling-hot, and then take it off the fire. When it ceases to boil, pour it on the plant of which you desire to have the Infusion; taking care there be enough of it to cover the plant entirely. Cover the vessel, and let your plant lie in the hot water for the space of half an hour, or longer if it be of a firm close texture. Then pour off the water by inclination: it will have partly acquired the colour, the smell, the taste, and the virtues of the plant. This liquor is called an *Infusion*.

To make the Decoction of a vegetable substance, put it into an earthen pan, or into a tinned copper vessel, with a quantity of water sufficient to bear being boiled for several hours, without leaving any part of the plant dry. Boil your plant more or less according to its nature; and then pour off the water by inclination. This water is impregnated with several of the principles of the plant, of which we shall take notice in the following observations.

OBSERVATIONS.

WATER, especially when boiling hot, is capable of dissolving, not only all that is purely saline in vegetables, but also a pretty considerable quantity of their Oil and of their earth, which, by contracting
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an union with the saline parts, have formed saponaceous, gummy, and mucilaginous compounds, that are soluble in water. After violent and long-continued boiling, therefore, there remains nothing in the plant but the purest oily part, and such as is the most fixed, that is, the most closely united with the earth of the plant. I say the most fixed: for some part of the oily matters, though not soluble in water, may be separated by the action of boiling water, when those matters abound greatly in the vegetable decocted; as we have seen happen to the Fat Oils of certain vegetable matters: but in that case these oily matters float upon the Decoction, and do not constitute a part of it.

From what we have already said, touching the analysis of plants, it seems evident, that, if those decocted be odoriferous and contain an Essential Oil, the Decoction will contain none, or at most but very little, of their Essential Oil, or their odorous principle; seeing we know that these substances cannot bear the heat of boiling water, without being carried off and entirely dissipated by it. Therefore, when we make a Decoction of an aromatic plant, containing an Essential Oil, we may be assured that it will not possess the virtues, either of the odorous part, or of the Essential Oil, and that it will have none but those of the other more fixed principles of the plant, with which it may be impregnated. The Decoction of such a plant perfectly resembles the water left in the cucurbit, after distilling its Essential Oil. But for those plants in which there are no such volatile parts, or whose virtue doth not reside in those principles, such as astringent and emollient plants, for example, that owe their properties wholly to an earthy Salt, or to a mucilage, they are capable of communicating their whole virtue to the water in which they are infused or decocted.

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If, on one hand, the Salts of plants render some portion of the principles of those plants soluble in water, such as part of their Oil and their earth, which if they were pure would not dissolve therein; on the other hand, these principles, being of their own nature indissoluble in water, hinder the Salts, by the union they have contracted together, from dissolving in it so easily, so soon, and in such quantities, as if they were pure. This is so true, that water, though boiled long and violently, is far from extracting out of plants all those parts that it is capable of dissolving. If, after boiling a plant in water, as directed in the process, this water be poured off, fresh water added, and a second decoction made in the same manner as the first, the water of this latter decoction will, by that means, be almost as strongly impregnated with the principles of the plant as the former was. Mr. Boerhaave was obliged to make twenty successive decoctions of the same plant, to wit, Rosemary, before the water came off the plant colourless and insipid; in a word, just as it was before the plant was boiled in it.

Mr. Boerhaave observes that a plant, after having thus given out all that water can dissolve, still retains exactly the same form that it had, before it underwent any of the many boilings necessary to exhaust it; that its colour, from being green at first, becomes brown; and that the plant, which when green is lighter than water, or at least doth not sink in it, is heavier after this operation, and falls to the bottom. This is a proof, that the water hath extracted out of the plant its lightest substances, assuming their places itself, and that it hath left nothing but its heaviest principles, namely its fixed oil and its earth. We shall afterwards examine more particularly these remains of plants exhausted by water.

If

If the Infusions and Decoctions of plants be filtered, and evaporated in a gentle heat, they become Extracts, that may be kept for whole years, especially if they be evaporated to a thick consistence; and better still if they be evaporated to dryness.

From what hath been said concerning the Infusions, Decoctions, and Extracts of plants, it follows, 1. that Infusions and Decoctions of aromatic plants do not furnish a complete Extract of those plants; because they do not contain the volatile and odorous parts, in which the principal virtue of such plants usually resides. If therefore you desire to make Extracts of such vegetables, that shall have no defect, you must employ their juices drawn by expression, or water impregnated with their principles by the means of trituration, and evaporate the liquor by spreading it over a great number of plates, in order to enlarge its surface, and quicken the evaporation, which must be effected by the heat of the sun alone, or the well-tempered warmth of a stove.

2. It may also be inferred, that water alone, aided by the degree of heat it is capable of acquiring by being made to boil, is not sufficient to effect the complete analysis of a plant; since not only some of its principles are still left combined in it, though exhausted as much as it can be by boiling water; but also several of the substances extracted from it by water are compounds of some of the principles of the plant, and susceptible of a much more accurate analysis; as we shall be convinced when we come to examine the effects which a degree of heat superior to that of boiling water is able to produce on entire plants, on their Extracts, and on their remains exhausted as much as they can be by boiling water.

But before we enter on that part of the analysis, it is proper to consider the experiments and combinations that may be made with the principles we have

have already obtained; in order to discover their nature, and in some measure analyze even them. Essential Oils in particular deserve to be thus examined.

We also obtain from certain plants, with a degree of heat less than that of boiling water, a Volatile Alkali, which exists formally in them: but as these plants, when analyzed, yield principles different from those we obtain out of all other vegetable substances, and as they resemble animal matters, we shall refer their analysis to a distinct chapter.

CHAP. V.

OF OPERATIONS ON ESSENTIAL OILS.

PROCESS I.

The Rectification of Essential Oils.

PUT into a cucurbit the Essential Oil you propose to rectify. Set the cucurbit in a *balneum mariæ*; fit to it a head of tin, or of copper tinned, together with its refrigeratory; and lute on a receiver. Make the water in the bath boil, and keep up this degree of heat till nothing more will come over. When the distillation is finished, you will find in the receiver a rectified Essential Oil, which will be clearer, thinner, and better scented, than before it was thus re-distilled; and in the bottom of the cucurbit will be left a matter of a deeper colour, more tenacious, more resinous, and of a less grateful smell.

OBSERVATIONS.

ESSENTIAL Oils, even the purest, the best prepared, and the thinnest, suffer great changes, and
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are much impaired by growing old: they gradually turn thick and resinous; their sweet, grateful scent is lost, and succeeded by a more disagreeable smell, somewhat like that of Turpentine. The cause of these changes is that their finest and most volatile part, that which contains most of the odorous principle, is dissipated and separated from that which contains least of it; which therefore grows thicker, and comes so much the nearer to the nature of a resin, as the quantity of Acid, that was distributed through the whole Oil before the dissipation of the more volatile part, is, after such dissipation, united and concentrated in the heaviest part; the Acid in Oils being much less volatile than the odorous part, to which alone they owe their levity.

Hence it appears what precautions are to be used, for preserving Essential Oils, as long as possible, without spoiling. They must be kept in a bottle perfectly well stopped, and always in a cool place, because heat quickly dissipates the volatile parts. Some authors direct the bottle to be kept under water.

If these Oils should grow thick and resinous by age, yet they are not to be thrown away. We shall shew in the analysis of Balsams and Resins, that, from these thick and even solid substances, Essential Oils may be drawn, as thin and as limpid as from plants. Essential Oils thickened by time may, therefore, be treated like Balsams, and actually analyzed, by separating all the subtile odorous matter they contain from their thick acid parts. For this purpose they need only be distilled with a degree of heat just sufficient to elevate the thin odorous parts, without raising the thick matter.

The residue left at the bottom of the vessel, because it could not rise in distillation, is much thicker and less odorous than the Oil was before rectification. The reason of this is evident, and follows from what hath just been said. This remainder

dissolves in Spirit of Wine more readily, and in greater quantity, than the light Oil drawn from it; because it contains more Acid, and because Oils owe their solubility in this menstruum to their Acid part, as is proved in our Memoir on Oils already quoted.

When we come to treat of Resins, we shall enquire more particularly what this remainder is, and what principles it yields when analyzed: in this place it is sufficient to take notice, that though all the Oil, of which it made a part, came over at first with the heat of boiling water, yet it cannot now be raised by the same degree of heat in distillation; because it is not now combined with the principle of odour which gives the Oil its volatility, and because it is rendered sluggish by being clogged with too great a proportion of Acid.

From what hath been already said it must be concluded, that Essential Oils suffer great diminution by being rectified; and that in proportion to the quantity of resinous matter left behind. All this resinous matter, while combined with a proper quantity of the odorous principle of the plant, (that is, at the time of its being distilled, and a little while after) was really an Essential Oil: the change of its nature therefore is entirely owing to its having lost that principle.

An Essential Oil, though rectified, is still as apt to change and be spoiled as before, because it still continues to lose its odorous principle by degrees. After some time, therefore, it requires a second rectification, which again lessens its quantity. In short, it is plain that Oils will, in a number of years, greater or smaller according to their nature, and the manner in which they are kept, be wholly changed, and metamorphosed into a resinous matter, from which no thin Oil can be drawn with the heat of boiling water: and this is a proof
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of the fugacity of that odorous principle, or *Spiritus Rectior*, of plants, which, when united with their lightest Oil, gives it the character of an Essential Oil.

This resinous matter, to which Essential Oils are finally reduced, being subjected to repeated distillations, with a degree of heat superior to that of boiling water, is still capable of yielding a certain portion of a thin, limpid, sweet-scented Oil, which is as light as an Essential Oil; as we observed before is the case with Fat Oils drawn by expression: but the thin Oil obtained by this means, though it possesses almost all the properties of an Essential Oil, is not for all that a genuine one; seeing it hath not the same odour with the plant from which it was originally drawn.

Essential Oils must be rectified in the *balneum mariæ*, as ordered in the process: for, as some of the Oil touches the sides of the vessel in the operation, if that vessel be made hotter than boiling water, the thick matter will rise with the thin Oil, which therefore will not be rectified.

Rectification is of use not only for procuring to Essential Oils the tenuity and levity they may have lost by age, but also to separate them from other oily matters with which they may be adulterated. If, for instance, an Essential Oil be not properly distilled; if, by the addition of too much Salt, the water have acquired a degree of heat greater than that of pure boiling water, and if, in consequence thereof, some of the heavy Oil of the plant have risen with the Essential Oil, and mixed therewith, the Essential Oil may, by rectification, be separated from this heterogeneous Oil; which, being heavier and incapable of rising with the heat of pure boiling water, will remain at the bottom of the vessel.

The effect will be the same, if your Essential Oil be falsified with a mixture of any Fat Oil, as is often the case: for, some of them being extremely dear, the vender frequently adds a portion of Fat Oil to encrease the quantity. For this purpose Oil of Ben is generally used.

When an Essential Oil is thus falsified with a mixture of any Fat Oil, it may be discovered by letting a few drops of it fall into rectified Spirit of Wine; which will dissolve the Essential Oil only, leaving the Fat Oil quite untouched.

Essential Oils are sometimes falsified by mixing them with a certain quantity of Spirit of Wine. This fraud doth not render their smell less fragrant: on the contrary, it becomes rather more agreeable and quicker. In order to try an Oil suspected of being falsified in this manner, drop a little of it into very clear water. If a milky cloud appear in the water, be assured the Oil is mixed with Spirit of Wine: for as this liquor unites more readily with water than with Oil, it quits the Oil with which it was mixed, to incorporate with the water: mean time a good deal of the Oil, that was dissolved by the Spirit of Wine, and is now separated from it by the intervention of water, necessarily remains dispersed through this water in very small particles; and these form the milky cloud produced on this occasion.

An Essential Oil may also be adulterated with another Essential Oil that is much more common, and of much less value. Those who practise this fraud generally employ Oil of Turpentine for that purpose, on account of its cheapness and tenuity. The cheat is easily discovered by moistening a linen rag with the Oil supposed to be thus falsified, and then holding the rag a little before the fire, which presently dissipates the odorous part of the falsified Oil. This odour, which prevented our distinguishing
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that of the Oil of Turpentine, being vanished, the peculiar smell of the Turpentine, which is much more permanent, remains alone; and is so perceptible that it cannot easily be mistaken.

Those, who are much accustomed to see and examine Essential Oils, have seldom occasion to make the experiments here proposed for discovering their qualities. A certain degree of thickness, partaking of unctuousity, in an Essential Oil, convinces them that it is falsified with a Fat Oil: on the other hand, a greater degree of tenuity, together with a quicker smell, than a pure Essential Oil ought to have, discovers the admixture of Spirit of Wine. Lastly, any one, whose sense of smelling is not very dull, will easily discover the odour of the Oil of Turpentine, though disguised by that of the Essential Oil with which it is mixed.

P R O C E S S II.

To fire Oils by combining them with highly concentrated Acids: instanced in Oil of Turpentine.

MIX together, in a glass, equal parts of concentrated Oil of Vitriol, and highly smoking fresh-drawn Spirit of Nitre: pour this mixture at several times, but suddenly, on three parts of Oil of Turpentine, set for that purpose in a glass basin. By a part here must be understood a dram at least. A most violent commotion, accompanied with smoke, will immediately be raised in the liquors, and the whole will take fire in an instant, flame, and be consumed.

O B S E R V A T I O N S.

THERE is not in Chymistry a phenomenon more extraordinary, and more surprising, than the firing of

Oils by mixing them with Acids. It could never have been suspected that a mixture of two cold liquors would produce a sudden, violent, bright, and lasting flame, like that we are at present considering. Beccher gave notice, in his *Physica Subterranea*, that highly rectified Spirit of Wine would be set on fire by mixing it with highly concentrated Oil of Vitriol.

Afterwards Borrichius, a Danish Chymist, published a process for kindling Oil of Turpentine by mixing it with the Nitrous Acid, as we find in the Philosophical Transactions of Copenhagen for the year 1671. Most Chymists have since tried to repeat those experiments, and particularly to fire the Oil of Turpentine by mixing it with Oil of Vitriol, or Spirit of Nitre; but to no purpose, when they made use of the Oil of Vitriol, till Mr. Homberg told us, in the Memoirs of the Academy of Sciences for 1701, that he had fired Oil of Turpentine by mixing it with Oil of Vitriol.

To make the experiment succeed, he requires
 “ that the Oil of Vitriol be dephlegmated as much
 “ as possible, and that the Oil of Turpentine be
 “ the last that comes over in distillation, which is
 “ thick like a syrup, and of a dark-brown colour;
 “ for that which is white, and rises at the beginning
 “ of the distillation, never takes fire.” These are his own words: but nobody else hath ever succeeded in making the experiment.

Tournefort had succeeded, a little before Homberg, in firing, not Oil of Turpentine indeed, in which he always failed, but the Oil of Sassafras, by mixing it with an equal quantity of well dephlegmated Spirit of Nitre. Homberg came afterwards, as appears by the Memoirs of the Academy for the year 1702, to fire with Spirit of Nitre the Essential Oils of the aromatic plants of India; and in 1706 Mr. Rouviere fired, with Spirit of Nitre,
 the

the empyreumatic Oil of Guaiacum. While this Oil of Guaiacum is burning, a porous spongy body rises from the midst of the flame, to the height of about two foot above the vessel.

Lastly, several years after all these discoveries, Messrs. Geoffroy and Hoffman, the one at Paris, and the other at Hall in Saxony, found a way to fire the Æthereal Oil of Turpentine, each by a different process; yet agreeing in this, that they both combined the Vitriolic Acid with the Nitrous, and with this compound Acid fired that Æthereal Essential Oil, which is one of the thinnest, and, probably for that very reason, the most unfit to produce a flame with Acids.

The most celebrated Chymists, as appears from this short account, have employed themselves in firing Essential Oils; but nobody attempted the experiment on Fat Oils. It was not so much as suspected that they were capable of taking fire after this manner, till in 1745 I read before the Academy a Memoir on Oils, which I have already mentioned, and in which I express myself thus :

“ I put two ounces and a half of Walnut Oil
 “ into the bottom part of a broken retort, having
 “ the figure of a cap or concave hemisphere; and
 “ poured thereon two ounces of smoking Spirit of
 “ Nitre. It was scarce put in when a considerable
 “ ebullition arose, with a very thick smoke. As I
 “ found it continually increasing, and very fast too,
 “ I retired a little, that I might observe the event
 “ without danger. This caution was not unnecessary:
 “ for immediately the whole mixture blew up
 “ as high as the cieling, with a noise like the discharge
 “ of a musket. Nothing was left in the
 “ vessel but a black matter, which still continued
 “ to boil a little and run over, and at last remained
 “ very rare, spongy, and as full of holes as a
 “ honey-comb: its consistence also was such that it

“ did not stick to my fingers when I handled
“ it.

“ As Mr. Geoffroy, who first found the means
“ of firing the natural Balsams, observed in them
“ a similar explosion on that occasion, it appears
“ that my Oil was very near taking fire in this ex-
“ periment; which makes me presume that we may
“ at last succeed in firing Fat Oils likewise, and
“ consequently all others; seeing these have al-
“ ways been looked upon as the most unlikely to
“ produce that phenomenon. I imagine that, to
“ accomplish this, nothing more is necessary than
“ to make use of sufficiently great quantities, and
“ to order it so that the surfaces of the liquors,
“ where they come into contact, may be of a large
“ extent.”

Afterwards, in 1747, Mr. Rouelle read before the Academy a Memoir on the accension of Oils by Acids. That Memoir contains a great number of curious experiments, and peculiar manual operations described very distinctly, from which there results a general method of firing without fail, not only Essential Oils, but even any Fat Oil whatever: so that my conjecture, concerning the possibility of firing these latter Oils, mentioned in my above-cited Memoir of 1745, is now changed into a certainty. I shall proceed to explain how I conceive these accensions are brought about, and endeavour to account for the phenomenon from such causes as to me seem the most probable.

A due attention to the phenomena produced by mixing Oils with Acids will enable us, I imagine, to discover the natural cause why the Oils take fire. It is certain, and demonstrated by the most decisive experiments, that the friction of several bodies rubbing against each other produces heat; and that when those bodies are combustible, and the heat produced by their friction rises to a certain degree, they

they take fire. This, in my opinion, is what happens to Oils when mixed with concentrated Acids. When these two sorts of substances rush into union with rapidity, as in the experiments under consideration, there must necessarily be a great friction among their parts. This friction produces the heat observed at the time of their union. The more concentrated the Acids are, with the greater violence and rapidity do they act upon the Oils, and the greater is the heat raised. If the Acids be concentrated to such a degree as to produce, by uniting with the Oils, a heat equal to that of an ignited body, the combustible substances that are exposed to it, which in this case are Oils, must needs take fire and flame.

The heat produced on this occasion is so great, that, even when the inflammation doth not take place, if you touch the surface of the Oil with your finger, as soon as the Acid hath had its effect, you will find it burn you like a live coal.

Two pieces of wood, rapidly and violently rubbed against each other, take fire. What is it that is kindled in this case? It can be nothing but their Oil; for they contain no other combustible principle. Why doth this Oil take fire? I do not think it possible to assign any reason for it, but the heat produced by the friction of the pieces of wood containing the Oil. If, when Oil is dispersed in a body, of which it is only one component principle, and consequently mixed with many saline, aqueous, and earthy parts, that are not inflammable, but, on the contrary, make the Oil less so, the Oil nevertheless takes fire, and burns when agitated by a sufficient degree of heat; why shall not this very Oil, when separated from the mixt of which it made a part, when united into one distinct mass, and entirely, or almost entirely, freed from the heterogeneous, incombustible parts with which it was combined,

bined, and consequently now more inflammable than before; why, I say, shall it not take fire, when exposed to a degree of heat equal, or rather superior, to that which is produced by rubbing two pieces of wood together?

Let us now examine the phenomena produced when Oils are fired by Acids, all the circumstances that favour or hinder their accension, and see if they agree with the explanation here offered.

First, no sort of Oil will take fire with any Acid whatever that is not highly concentrated; for weak Acids act but feebly on Oils, and dissolve them slowly; so that the friction is neither quick nor violent, and consequently produces too faint a heat, far below the degree of ignition.

Secondly, no inflammation is produced when Acids and Oils are mixed in too small quantities; but the more Acid and Oil you mix together, the greater is the certainty of succeeding: for the heat is exactly in proportion to the friction that produces it; and the total quantity, or amount, of this friction is so much the greater, as there are more particles rubbing against each other at the same time. So that if a very small quantity of Acid and Oil be mixed together, there will be but a very small quantity of friction, and consequently a very small quantity of heat; and in that case no inflammation. It was with a view to avoid these inconveniences, and to procure the opposite advantages in as great a degree as possible, that, in the passage above quoted from my Memoir of Oils, I proposed mixing together large doses of Acid and of Oil, as one of the means by which we might succeed in the accension of Fat Oils.

Thirdly, the figure of the vessel, in which the two liquors are mixed together, is not a matter of indifference. A wide-spreading vessel, of a large diameter with respect to the quantity of liquor it is

to contain, favours the inflammation much more than one of a small diameter. Nay, it may not succeed at all in too narrow a vessel, though all other circumstances be properly attended to.

The reason of this is, that the activity of heat produced by friction is not in proportion to the successive, but to the simultaneous frictions: for the heat actually produced by the frictions of an hundred particles, rubbing successively against each other, with intervals sufficient to let the heat go off, almost as fast as it is generated, would be equal to the friction of a single particle only; whereas the heat actually produced by the friction of the same number of particles, all rubbing against each other at the same instant, would be equal to the frictions of all the particles taken together, and consequently an hundred times more active than the other *. This being laid down, it is easy to conceive how a large vessel favours the accension more than a small one. It is certain that two liquors which mutually present large surfaces to each other, at the instant of their being mixed together, touch each other at one and the same time in a much greater number of points, than if each had but a small surface; and consequently that they must unite much sooner, and with greater rapidity, in the former case than in the latter.

* I believe this proposition is not strictly true: for it appears to me, that, in order to make the heat, produced by the simultaneous frictions of an hundred particles, an hundred times more active than that produced by the successive frictions of the same number of particles, it is necessary that the simultaneous frictions should act all together in one point or center; which is impossible. But, as the particles that rub against each other, in the present case, are very near and contiguous, it is still true that the heat, resulting from their simultaneous frictions, is much more active than that produced by successive frictions only; which is sufficient for our present purpose.

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With these views, and in order to give the liquors this advantageous disposition, I recommended it as what would greatly promote the inflammation of Fat Oils, to order the liquors so, that, at the moment of their mixture, a large surface of each might come into contact with the other.

Fourthly, if we reflect on the experiments hitherto made for kindling Oils by Acids, we shall easily be convinced that all Oils are not equally apt to be fired; and that light, æthereal, very thin, Essential Oils do not produce this phenomenon so readily and so surely, as those of the same kind that are heavy and thick, or at least soon grow thick upon being mixed with Acids.

Mr. Homberg says positively in the above-cited passage of his Memoir, that he never could succeed in setting fire with the Acid of Vitriol to the white æthereal Oil of Turpentine; that is, to the lightest which comes over first in distillation; but that the very same Acid set fire to “that which comes over last in distillation, which is thick like a syrup, and of a dark brown-colour.”

All the experiments by which Oils have been fired, from those of Beccher and Borrichius, down to those of Geoffroy and Hoffman, were made on the Essential Oils of the aromatic plants of India, which are the heaviest we know, and on the empyreumatic Oil of Guaiacum, which, besides being very ponderous, is also very thick.

Now these singular effects likewise agree perfectly well with our explanation. It is certain that the parts of a heavy fluid do not yield to any impulse or shock, so easily as those of a lighter fluid; just as the parts of a thick, viscous fluid undoubtedly resist any attempt to separate them, so much the more the nearer the consistence of that fluid is to solidity, or the further it is removed from the state of fluidity. Now, the more resistance the
Acid

Acid meets with in separating and dividing the parts of the Oil, as it must do to dissolve them, the more considerable will be the force and motion with which it must necessarily act to surmount those obstacles; besides, as experience teaches us that the density and viscosity of the Oils do not, at least to sense, diminish the quickness and activity which the Acid exerts in uniting with them; the greater therefore must be the collisions, frictions, and heat produced: and this plainly shews why heavy, thick Oils take fire, in this case, more readily than those which are fluid and light.

It may here be objected that Fat Oils, which are thicker and heavier than the light Essential Oils, take fire nevertheless with greater difficulty. This objection is easily answered, by observing that when we say Acids fire heavy thick Oils with more ease than thin light Oils, this position must be restricted to Oils of the same kind, on which Acids have an equal, or nearly equal, action; that is, to such Oils as differ from each other in no other respect but their thickness and weight.

For example, Mr. Homberg, who could by no means set fire, with Oil of Vitriol, to the Oil that rises first in the distillation of Turpentine, found that the same Acid would fire the Oil that comes last over: and therefore it is reasonable to attribute his success, in firing this last Oil, to its being thicker and heavier than the former; seeing these two Oils are in other respects of the same nature; that Acids have an equal action on both; and that they differ from each other only in the qualities specified above.

But it is evident, that, if the Oils compared together be of different kinds, and differ from each other, not only in weight and thickness, but also by containing different principles, or, at least, the same principles combined differently, and in different

ferent proportions, the action of any Acid on those Oils must also be different; and that regard must be had thereto in determining their degrees of inflammability.

Now all this is applicable to Fat Oils, when compared with light Essential Oils, in point of inflammability. If all these Oils were of the same nature, and differed from each other in weight and thickness only, the objection drawn from Fat Oils, which though thicker than Essential Oils do not take fire so easily, would be a very good one, and fact would be against our reasoning. But this is far from being the case: the properties, as well as the analysis, of Fat Oils, shew their nature to be very different from that of Essential Oils; that there is more water in their composition; and that they are full of a mucilaginous or gummy principle, which must greatly obstruct their inflammability, and the action of Acids upon them.

None of the effects therefore, that attend the firing of Oils with Acids, is repugnant to our way of accounting for the phenomenon, which is one of the most beautiful in all Natural Philosophy. To conclude this important subject, nothing now remains but to consider the effects produced by the Vitriolic Acid in these accensions.

This Acid, though of a stronger nature, and capable of being more highly concentraed than the Nitrous Acid, seems however less qualified to produce a flame with Oils. Indeed Mr. Homberg fired Oil of Turpentine by mixing it with Oil of Vitriol: but I do not know that the experiment hath succeeded with any other Chymist; on the contrary, most of those who have tried it affirm that they never could fire any Oil with that Acid alone.

Oils are probably in the same case as metallic substances, with regard to these two Acids. We know that the Nitrous Acid dissolves those substances
with

with vastly more activity and violence than the Vitriolic Acid exerts upon them; which may depend either on the disposition and configuration of their parts, or on the portion of phlogiston which, according to the opinion of most Chymists, is united with the Nitrous Acid, is its peculiar characteristic, and the cause of the great vivacity with which it dissolves almost all matters that contain the phlogiston.

I say *almost* all matters that contain the phlogiston; because there are some substances that contain a great deal thereof, and yet are not at all acted on by the pure Nitrous Acid. These substances are matters perfectly charred: that is, such as are capable of enduring the greatest violence of fire in close vessels, without yielding a single atom of Oil; that burn almost quite away, yet only grow red-hot without flaming; or at least produce but a very small, slight flame, from which it is impossible to obtain the least particle of soot or fuliginosity; in a word, that contain an inflammable matter, but such as is fit to be an ingredient in the composition of metallic substances, to which the peculiar title of the phlogiston is appropriated.

I say then that, if the Nitrous Acid be poured on a mere coal, perfectly charred, it is impossible for the Acid, be it ever so highly concentrated, to set the coal on fire, though heated before to the greatest degree that it can possibly admit of without kindling; and, which is still more remarkable, if a live coal be plunged into the most highly smoking Spirit of Nitre, it will be extinguished as if dipt in pure water.

But to return to the Vitriolic Acid: it is singular enough that this Acid, which attacks Oils with less activity, and for that reason seems less fit to set them on fire, than the Nitrous Acid, yet greatly promotes their accension, when mixed with that very
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Acid.

Acid. This may be owing to its rendering the Oils with which it mixes heavier and thicker ; or else, as Mr. Rouelle conjectures with great probability, being more concentrated than the Nitrous Acid, and having a greater affinity with water, it dephlegmates the other, and thereby increases its activity ; or lastly, this may arise from some other cause yet unknown to us, and perhaps from that by which the Acids of Nitre and of Sea-salt, which, when separate and perfectly pure, can neither of them dissolve Gold, are enabled, when combined together, to make a perfect solution of that metal.

P R O C E S S III.

To combine Essential Oils with Mineral Sulphur. Balsam of Sulphur. This composition decomposed.

PUT into a matrafs one part of Flowers of Sulphur ; pour on them six parts of the Essential Oil of Turpentine, for instance ; set the matrafs in a sand-bath, and heat it gradually till the Oil boil. The Sulphur, which at first lay at the bottom of the matrafs, will begin to melt, and appear to dissolve in the Oil. When it hath boiled in this manner for about an hour, take the matrafs from the fire, and let the liquor cool. A great deal of the Sulphur that was dissolved therein will separate from it as it cools, and fall to the bottom of the vessel in the form of needles, much like a Salt shooting in water.

When the liquor is perfectly cold, decant it from the Sulphur that lies at the bottom of the vessel : to that Sulphur put fresh Oil of Turpentine, and proceed as before : the Sulphur will again disappear, and be dissolved in the Oil : but when the mixture is cold, you will find new crystals of Sulphur deposited

ed at the bottom. Decant once more this Oil from the crystals, and pour on fresh Oil to dissolve them: continue the same method, and you will find that about sixteen parts of Essential Oil are required to keep one part of Sulphur dissolved when cold. This combination is called *Balsamum Sulphuris Terebinthinatum*, if made with Oil of Turpentine; *Anisatum* if with Oil of Anise-seeds; and so of others.

OBSERVATIONS.

ESSENTIAL Oils do not dissolve Sulphur, in such quantities, and with so much ease, as Fat Oils do. It was shewn above that a Fat Oil is capable of keeping a considerable quantity of Sulphur in solution; whereas no less than sixteen parts of Essential Oil are required to dissolve one part only of Sulphur, as in this process.

The property which Sulphur hath of separating, in part, from the Essential Oil in which it is dissolved, and falling to the bottom of the vessel in the form of crystals, as the Oil cools, proves that it is a kind of Neutral Salt, which, being insoluble in water because of the great quantity of inflammable matter that serves it for a basis, is not to be dissolved but by substances that actually contain themselves a great deal of inflammable matter; such as Oils and Metallic substances.

Though the latter are almost always solid, it nevertheless unites with several of them into regular forms, resembling saline crystals in every thing but pellucidity; as appears, for example, in several Pyrites, Antimony, and some other sulphureous Minerals. But when it is dissolved in Oils, especially in such as are capable of keeping but a small quantity thereof in solution, and consequently drop a good deal of it as they cool, it is precisely in the case of one of those Salts whereof hot water dissolves more than cold; that is, the Oil, that is saturated

with as much Sulphur as it can possibly take up when boiling hot, lets some part thereof precipitate as it cools; while the Sulphur thus separated from the Oil unites into little glebes of a regular figure, and actually crystallizes; in the same manner as Nitre, when boiling water hath dissolved as much thereof as it can possibly take up, partly separates from it when it cools, and falls to the bottom of the vessel in small crystalline *moleculæ*, of the form peculiar to that Salt.

M. Homberg made some very curious experiments on this combination of Sulphur with an Essential Oil. In the Memoirs of the Academy he gives the following analysis thereof.

“ Put your Sulphur dissolved by Oil of Turpentine into a pretty large retort, because the matter
 “ puffs up towards the end, and distill with a very
 “ gentle heat for twelve or fifteen days and nights.
 “ There will come over about two thirds of the
 “ quantity of a colourless Oil of Turpentine, and
 “ at the same time a *pretty considerable quantity* of a
 “ whitish ponderous water, as acid as good Spirit
 “ of Vitriol. After this the drops of Oil that
 “ come off will begin to be red. Then change
 “ your receiver, and increase the fire gradually;
 “ and in seven or eight hours time, with a very
 “ great heat, force off all that will rise, using a
 “ glass retort for your recipient. At last, most of
 “ the Oil will come over into the receiver very
 “ thick and high-coloured, still accompanied with
 “ a whitish and very acid water. In the retort will
 “ be left a black *caput mortuum*, spongy, or foliated,
 “ shining, and insipid. . . . This *caput mortuum*
 “ neither grows white, nor flames, nor wastes considerably in a strong fire.

“ The matter that comes over into the receiver
 “ must be distilled again, with a very gentle heat
 “ continued for several days and nights, in order
 “ to

“ to separate once more the colourless Oil and the
 “ remaining acid water, till the Oil begin to come
 “ off red. Then take the retort from the fire, and
 “ on the black gummy matter left in it pour good
 “ Spirit of Wine; mix the whole well together,
 “ and distill with a very gentle heat. When this
 “ Spirit of Wine is come off, pour some fresh on
 “ the black gum left in the retort, and distill as
 “ before. Repeat this till the Spirit of Wine cease
 “ to have a bad smell.”

There is great reason to believe, that, by the union which the Sulphur contracts with the Oil, the cohesion of the Acid and the Phlogiston, which constitute that mineral, is considerably weakened; and that this is what occasions the decomposition of the Sulphur so manifest in M. Homberg's analysis. The inflammable matter of the Sulphur is so incorporated with that of the Oil in the solution, that they form together one homogeneous whole; by which means the Acid of the Sulphur, which is of course dispersed through the whole liquor, is not now combined with the Phlogiston, as it was in the Sulphur before it was blended with the Oil; that is, with the pure Phlogiston; but with that Phlogiston which constitutes the oily mixture, or, which is the same thing, with actual Oil. And this is the reason that a composition of Oil and Sulphur yields, in distillation, nearly the same principles that a combination of the same Oil with the Vitriolic Acid would yield.

We have already seen, under the head of Fat Oils, that when Oils are combined with Acids, if this combination be again decomposed by distillation, those two substances cannot be obtained in their original state; but that they are changed and partly decomposed. The case is the same in the experiment before us. We first get, by distillation, a pretty considerable quantity of Oil of Turpentine,

that seems to have suffered no change at all. This first Oil is that which the action of fire separates from the Acid; and this it effects with so much the more ease, that, a great quantity thereof having been necessarily used to dissolve a little Sulphur, it greatly exceeds the quantity of Acid in the mixture, and that the distillation is ordered to be made with a very weak degree of heat: for M. Homberg says it ought to be continued twelve or fifteen days and nights. Now this manner of distilling, with a very gentle heat, is the most effectual means of separating Oils, especially light Essential Oils, from Acids; because these Oils rise in distillation with very little heat; whereas the Acids, being much more ponderous, require a great deal more.

The Oil that rises first in distillation appears indeed to be the same with that which was originally used in the mixture: but the quantity is much smaller: first, because some part of it, being combined with the Acid of the Sulphur, is thereby rendered thick and heavy, which hinders it from rising in this first distillation with a very gentle heat, and is the reason that it cannot be elevated without a much stronger degree of fire. It is this part that afterwards comes over in the form of a red liquor upon encreasing the fire.

The second cause why the quantity of Oil is lessened is, that part of it is decomposed in the operation. This decomposed part of the Oil furnishes that considerable quantity of water which ascends at the same time with the Oil, or a little after it, and serves for a vehicle to the Acid that rises with it in this first distillation; which Acid, though pretty strong, is now much more loaded with water than when it was an ingredient in the combination of Sulphur. This acid water is of a milky white colour, because many oily particles are suspended and diffused in it, but not perfectly dissolved.

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The *caput mortuum* that is left in the retort, after all the red thick Oil is driven up by a very strong degree of fire, is a sort of charred matter, consisting of some of the earth of the Sulphur, and of the decomposed Oil, united with a Phlogiston, which is probably furnished by both these substances. This matter contains also a little Acid fixed with it. This Acid re-produces Sulphur, or at least becomes sulphureous, and flies off in vapours, when the coal is urged by a violent forge-heat: for Mr. Homberg observed that by this means it exhaled an odour of Sulphur, and lost in weight.

This charred matter is of a singular nature: for, by being exposed to a forge-heat, and even to the heat in the focus of a burning-glass, it seemed to suffer no other change than some loss of weight, occasioned by the evaporation of the acid effluvia carried off by the heat; for it still retained its black colour, and was neither consumed nor vitrified. In order to melt it, Mr. Homberg was forced to mix it with Borax. This Salt converted it into a glass of a dark-grey colour: and, as there appeared a little verdegriis on the surface of this glass after keeping it in a moist place, he thereby found that the Sulphur he had used contained a little Copper.

We know that the earth of Copper is refractory, and that it communicates a dark colour to matters vitrified along with it: and perhaps it was the cause why the fixed matter in question retained its blackish colour so obstinately, notwithstanding the Phlogiston that must have been in it at first was, in all probability, consumed by the violent ignitions it underwent.

As to the thick oily matter called *gummy* by Mr. Homberg, from which he directs Spirit of Wine to be repeatedly distilled, till it cease to have a disagreeable smell, there is great reason for thinking it to be, as we said before, a portion of the

Oil which the Acid hath rendered thick and heavy. The Spirit of Wine dissolves and carries up the most acid part, which always hath a disagreeable smell.

Mr. Homberg says that “ the part remaining
“ after this, which he calls the *Gum of common Sul-*
“ *phur*, hath a pleasant balsamic odour; that it
“ partly dissolves in Spirit of Wine, a hard resinous
“ matter being left, which will not dissolve, either
“ in Spirit of Wine, or in the strongest lixivium.”
Of consequence therefore it is neither a resinous matter, nor a sulphur; “ yet it dissolves perfectly in
“ distilled Oils.” What then is this singular body? It is certainly a subject for very curious enquiries. In general, Mr. Homberg’s whole process is full of interesting facts, and well deserves to be repeated, carried further, and carefully attended to.

P R O C E S S IV.

To combine Essential Oils with Fixed Alkalis.
Starkey’s Soap.

TAKE Salt of Tartar, or any other Alkali, thoroughly calcined. Heat it in a crucible till it be red, and in that condition throw it into a hot iron mortar: rub it quickly with a very hot iron pestle; and as soon as it is powdered pour on it, little by little, nearly an equal quantity of Oil of Turpentine. The Oil will enter into the Salt, and unite intimately with it, so as to form a hard paste. Continue rubbing this composition with the pestle, in order to compleat the union of the two substances; and, as your Oil of Turpentine disappears, add more, which will unite in the same manner, and give a softer consistence to the soapy mass. You may add still more Oil, according to the consistence you intend to give your Soap.

O B S E R-

OBSERVATIONS.

ESSENTIAL Oils do not unite near so easily as Fat Oils with Alkalis. For this reason, to make a Soap with an Essential Oil, we must take a method different from that used in common soaperies. For if an Essential Oil be substituted for the Fat Oil, in the ordinary way of making Soap, far from combining with the alkaline lixivium, though ever so strong, it will be wholly dissipated and vanish: so that, after boiling some time, you will find nothing but the lye just as when first put in, only a little more concentrated.

The water, in which the Alkali is dissolved when in the form of a lye, is the principal thing that hinders the Salt from uniting with the Essential Oil. Water is such an enemy to this union, that, if the Alkali be ever so little moist, the operation will not succeed; even though all the other precautions mentioned in the process should be exactly observed.

In order therefore to free the Alkali from all humidity, it is necessary to begin with making it red-hot; and then, that this Salt, which is very greedy of moisture, may not imbibe any from the air, before it be mixed with the Essential Oil, it must not be suffered to cool; but the mixture must be made in a hot vessel, as soon as the Salt is reduced to powder. When every particle of the Salt is once covered with Oil, you need not fear its attracting any moisture, at least very quickly, because the Oil opposes its admission.

Starkey, the first Chymist who found the means of making Soap with an Essential Oil, and by whose name this kind of Soap is therefore called, made use of a much more tedious method than that proposed in our process. He began with mixing a very small quantity of Oil with his Salt, and waited till all the Oil united therewith of its own accord,

so as to disappear entirely before he added any more; and thus protracted his operation exceedingly, though in the main it was the same with ours. The method here proposed is more expeditious, and was invented by Dr. Geoffroy.

Starkey's Soap dissolves in water much as common Soap does, without any separation of the Oil; and by this mark it is known to be well made. It may also be decomposed, either by distillation, or by mixing it with an Acid: and its decomposition, in either of these ways, is attended with nearly the same phenomena as the decomposition of common Soap.

CHAPTER VI.

OF THE SUBSTANCES OBTAINED FROM VEGETABLES BY MEANS OF A GRADUATED HEAT, FROM THAT OF BOILING WATER, TO THE STRONGEST THAT CAN BE APPLIED TO THEM IN CLOSE VESSELS.

PROCESS I.

To analyze Vegetable Substances that yield neither a Fat nor an Essential Oil. Instanced in Guaiacum-Wood.

TAKE thin shavings of Guaiacum-Wood, and put them into a glass or stone retort, leaving one half thereof empty. Set your retort in a reverberating furnace, and lute on a large glass receiver having a small hole drilled in it; such as is used for distilling the Mineral Acids. Put a live coal or
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two in the furnacé, to warm the vessels gently and slowly.

With a degree of heat below that of boiling water, you will see drops of a clear insipid phlegm fall into the receiver. If you raise the fire a little, this water will come slightly acid, and begin to have a pungent smell. With a degree of fire somewhat stronger, a water will continue to rise which will be still more acid, smell stronger, and become yellowish. When the heat comes to exceed that of boiling water, the phlegm that rises will be very acid, high-coloured, have a strong pungent smell, like that of matters long smoked with wood in a chimney, and will be accompanied with a red, light Oil, that will float on the liquor in the receiver.

And now it is necessary that the operation be carried on very cautiously, and vent frequently given to the rarefied air by opening the small hole in the receiver; such an incredible quantity thereof rushing out of the Wood, with this degree of heat, as may burst the vessel to pieces, if not discharged from time to time.

When this red, light Oil is come over, and the air ceases to rush out with impetuosity, raise your fire gradually, till the retort begin to redden. The receiver will be filled with dense vapours; and together with the watery liquor, which will then be extremely acid, there will rise a black, thick, ponderous Oil, which will fall to the bottom of the receiver, and lie under the liquor.

Then give the utmost degree of heat; that is, the greatest your furnace will allow, and your vessels bear. With this excessive heat a little more Oil will rise, which will be very ponderous, as thick and black as pitch; and the vessels will continue full of vapours that will not condense.

At last, when you have kept the retort exceeding red for a long time in this extremity of heat, so that
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it begins to melt, if it be of glass, and you perceive nothing more come over, let the fire go out and the vessel cool. Then take off your receiver: from the black Oil at bottom decant the acid liquor with the red Oil floating on it, and pour them both into a glass funnel, lined with brown filtering paper, and placed over a bottle. The acid liquor will pass through the filter into the bottle, and the Oil will be left behind, which must be kept by itself in a separate bottle. Lastly, into another funnel, prepared as the former, pour the thick Oil remaining with a little of the acid liquor at the bottom of the receiver. This liquor will filter off in the same manner, and thus be separated from the heavy Oil.

In the retort you will find your Guaiacum-shavings, not in the least altered as to their figure, but light, friable, very black, scentless and tasteless, easily taking fire, and consuming without flame or smoke: in short, you will find them charred to a perfect coal.

OBSERVATIONS.

HITHERTO we have examined the substances that may be obtained from vegetables, either without the help of fire, or with a degree of heat not exceeding that of boiling water. The analysis of plants can be carried no further without a greater degree of heat: for, when the principle of odour, and the essential oil of an aromatic plant, are wholly extracted by the preceding processes, if the distillation be afterward continued without increasing the heat, nothing more will be obtained but a little Acid; which will soon cease, as a small part only of the quantity contained in the plant will be elevated; the rest being either too ponderous, or too much entangled with the other principles of the body, to rise with so small a degree of heat.

In order therefore to carry on the decomposition of a plant, from which you have, by the methods before

fore proposed, extracted all the principles it is capable of yielding when so treated; or, which comes to the same thing, in order to analyze a vegetable matter, which affords neither an expressed nor an essential oil, it must be distilled in a retort with a naked fire, as directed in the process, and be made to undergo all the degrees of heat successively, from that of boiling water, to the highest that can be raised in a reverberating furnace.

A heat inferior to that of boiling water, with which we must begin in order to warm the vessel gradually, brings nothing over, as hath been said, but an insipid water, destitute of all acidity. By increasing it nearly to the degree of boiling water, the distilled water comes to be slightly acid.

When the heat is made a little stronger than that which is necessary for the elevation of an Essential Oil, the Acidity of the water that comes off is much more considerable. It hath now both colour and smell, and there rises with it a red, light Oil, that floats on the liquor in the receiver. This is not an Essential Oil; it hath none of the odour of the plant. Though so light as to float on water, yet it will not rise with the degree of heat that raises Essential Oils, even those that much surpass it in gravity, and will not swim on water as this does. This proves that the ease or difficulty, with which a particular degree of heat raises any substance in distillation, doth not depend altogether on its gravity: its dilatibility, or the volatile nature of the matters, with which it is so closely united as not to be separated from them by distillation, may probably contribute greatly to produce this effect.

It is very surprising that a substance so hard, so compact, so dry, in appearance, as Guaiacum-wood, should yield such a large quantity of water by distillation; and it is equally so that it should discharge so much air, and with so much impetuosity, as no-

thing but experience could render credible. We have, in the process, directed the precautions to be taken when this air, from being prodigiously condensed in the body of which it made a part, is set at large, rushes out of confinement, and expands with all its natural elasticity. From this air arises the greatest danger attending the operation.

It hath been remarked that the heaviest and most compact woods yield the most air in distillation: and accordingly Guaiacum-wood, which we have chosen for an instance, as exceeding almost all others in hardness and weight, discharges a vast quantity of air when analyzed.

The thick, burnt, empyreumatic Oil, that comes over last in this distillation, is heavier than water; on account, probably, of the great quantity of Acid with which it is replete. The two kinds of Oil obtained in this analysis may be rectified, by distilling them a second time, or rather several times; by which means they will become lighter and more fluid, as we have seen happen to Fat and Essential Oils. In general, all thick, heavy Oils constantly owe these qualities to an Acid united with them; and it is by being freed from some of that Acid in distillation, that they always acquire a greater degree of lightness and fluidity from that operation. To these laws all vegetable Oils are subject, of what nature soever they be.

The analysis of a vegetable substance, exhibited above, shews what may be obtained from them, when distilled in close vessels, with a graduated heat, from that of boiling water, to that which converts the mixt to a perfect coal; viz. Phlegm, an Acid, a light Oil, much Air, and a thick Oil. But this analysis is far from being a complete one: it may be carried much farther, and made more perfect.

None of the principles obtained by this analysis are pure, simple, and thoroughly separated from
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the rest. They are still in some measure blended all together: their separation is but begun; and each requires a second and more accurate analysis, to reduce it to the greatest degree of purity of which it is capable. The Oil and the Acid chiefly merit so much pains.

A great deal of the Acid of the plant remains, as was said, combined with the two sorts of Oil here obtained; which we have reason to think differ no otherwise from one another, than as there is more or less Acid united with each. The best way of freeing these Oils from their redundant Acid is to distill them frequently from Alkalis and Absorbents. Some of our best Chymists have taken this pains with several sorts of Oils; but the method might be still extended, and the operation carried further than hath yet been done.

The Acid, is in the same circumstances nearly as the Oil. The first that rises is mortified with much water, to which it owes a good deal of its volatility. That which comes over last is much more concentrated, and consequently heavier; yet it is still very aqueous. It might be freed in a great measure from this adventitious water, and so rendered much stronger; which would give us a better opportunity to discover its nature and properties, of which we know but very little.

Water is not the only heterogeneous substance that disguises the vegetable Acid: a pretty considerable quantity of the Oil of the plant is also combined with it, and contaminates its purity. The proof of this is, that, when these Acids are kept, in the same condition in which they first come over, for any length of time, in a glass vessel, they gradually deposit, on the bottom and sides of the vessel, an oily incrustation, which grows thicker and thicker the longer it stands; and, as this oily matter separates

separates from it, the Acid liquor appears less unctuous and saponaceous.

A very good way to separate this Oil more effectually from the Acid is to combine the whole with absorbents, and abstract the Oil again by distillation. By this means a very sensible quantity of Oil may be separated that was not perceived before. On this occasion it is proper to remark that the Oil thus united with the vegetable Acid is perfectly dissolved by it; seeing it is thereby rendered miscible with water, so that it doth not, like Alkaline Soaps, in the least obscure its limpidity, or give it a milky cast: for these aqueous, oily Acids are very transparent; especially after they have stood for some time.

The air, that is discharged with impetuosity in the operation, and must be let out, is loaded with many particles of Acid and Oil reduced to vapours, which it carries off; and by this means the quantity of the principles extracted from the mixt cannot be accurately determined: nor are the vapours, of which the vessels remain full after the operation, any other than particles of Acid and Oil, which the violence of the fire hath rarefied exceedingly, and which do not easily condense.

If we distill in this manner a vegetable aromatic substance, which of course contains an Essential Oil, provided it hath not been previously extracted by the appropriated process, this Essential Oil will rise first, as soon as the distilling vessel acquires the heat of boiling water: but its scent will not be near so sweet or grateful, as if it were distilled in the manner before directed as properest for it. On the contrary, it will have an empyreumatic smell: because in this way it is impossible to avoid scorching, and half-burning some of the matter distilled; especially that part of it which touches the sides of the retort. Moreover, the very same equable degree of heat can
hardly

hardly be kept up with a naked fire. The Essential Oil therefore, though it rises first, will not be pure, but contaminated with a mixture of the empyreumatic Oil that first comes over, and will be confounded therewith.

If a substance abounding with Fat Oil, that hath not been expressed from it, be distilled according to the present process, it will yield no Fat Oil by distillation; but only much more of the first clear Oil, and of the second thick Oil, than if all the Fat Oil it would have afforded had been first drawn off by expression; for as the Fat Oil will not rise in distillation, without a degree of heat greater than that of boiling water, neither can it endure such a degree of heat without changing its nature, without losing that mildness, and, in a great measure, that unctuousity which is natural to it. It will therefore be confounded with the other empyreumatic Oil, which, in all probability, would itself be no other than a Fat Oil, if it could be wholly extracted, without the aid of fire, from the vegetable substances containing it.

Most vegetable substances, when distilled with a strong fire, yield the same principles with that which we have chosen for an instance. Entire plants of this kind, those from which the odorous principle, the Essential Oil, or the Fat Oil, hath been drawn, those of which extracts have been made by infusion or decoction, or the extracts themselves; all such matters being distilled, yield a Phlegm, an Acid, a thin Oil, Air, and a thick Oil; and the products of their several analyses differ from each other, only on account of the different quantity or proportion that each contains of the principles here enumerated.

But there are many other plants, which, besides these substances, yield also a considerable quantity of a Volatile Saline Salt. This property is possessed chiefly by that class of plants which is distinguished
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by having cruciform flowers; among which there are some that being analyzed, greatly resemble animal matters. We shall now analyze one of these; Mustard-seed for instance.

PROCESS II.

To analyze a vegetable Substance which yields the same principles as are obtained from Animal matters: instanced in Mustard-seed.

WITH an apparatus like that of the preceding process, and with the same fire, distill Mustard-seed. With a degree of heat inferior to that of boiling water, there will come over a phlegm somewhat coloured, and impregnated with a Volatile Alkaline Salt. With a degree of heat greater than that of boiling water, the same kind of phlegm, impregnated with the same Salt, will continue to come over; but it will be much higher coloured, and will be accompanied with a light Oil. At this time a considerable quantity of air is discharged; with regard to which, the same precautions must be taken as in distilling Guaiacum.

If the fire be gradually raised, there will come over a black, thick Oil, lighter however than water; and at the same time vapours will rise, and, condensing on the sides of the receiver, form into sprigs or ramifications. This is a Volatile Alkaline Salt, in a concrete form, like that of Animals, as we shall hereafter see. These vapours are much whiter than those of Guaiacum.

When you have thus drawn off, with a very strong fire, all the Volatile Alkali and thick Oil contained in the subject, there will be nothing left in the retort but a sort of coal, from which a small quan-

quantity of Phosphorus may be obtained, provided the retort you employ for that purpose be good enough to stand a very violent heat.

OBSERVATIONS.

MUSTARD-SEED furnishes us with an instance of a vegetable, from which we obtain, by analyzing it, the very same principles that animal matters yield. Instead of getting an Acid from it, we obtain only a Volatile Alkali; probably because the Acid, which originally enters into the composition of this kind of vegetables, as well as of all others, undergoes, in passing through their strainers, and mixing with their juices, such alterations as it suffers when it enters into the composition of animals; that is, it combines with some of their Earth and of their Oil, in such a manner as to be changed into a Volatile Alkali, or at least disposed to be converted into one with the aid of fire.

We shall not here speak of the manner of separating and depurating the principles obtained by this process; but reserve it for the analysis of animals, which is absolutely the same. We shall content ourselves with observing that the first Volatile Alkali which rises at the beginning of the operation together with the phlegm, in a degree of heat below that of boiling water, differs from that which doth not come over till towards the end of the distillation, when the last thick Oil ascends. The different times, and different degrees of heat, in which these two Alkalies rise, shew that the former exists actually and perfectly in the plant; but that the latter is generated during the distillation, and is the product of the fire, which combines together the materials whereof it is composed.

Vegetables, that thus yield a Volatile Alkali with a heat less than that of boiling water, irritate

the organ of smelling, affecting it with a sensation of acrimony; and the effluvia, which rise from them when bruised, make the eyes smart so as to draw tears from them in abundance. Several of these matters, being only bruised, effervesce with Acids: effects producible only by a very Volatile Alkaline principle.

This is that Alkali, the lightest of all the principles that can be extracted from bodies, which rises first in our distillation along with the phlegm, and with a degree of heat much inferior to that of boiling water. As the phlegm with which it rises is very copious, it is dissolved thereby; which is the reason it doth not appear in a concrete form. To this water it gives a slight yellowish tinge, because it is impure and oily. The saline Alkaline properties of this liquor have procured it the title of a Volatile Spirit. This Volatile Alkali, which exists naturally and perfectly formed in Mustard-seed, Onions, Garlick, Cresses, and other such vegetables, constitutes a difference between them and animal substances, which contain only the materials requisite to form a Volatile Alkali, but none ready formed, unless they have undergone the putrid fermentation.

The second Volatile Alkali, which rises in our distillation, but not without a very strong degree of fire, and at the same time with the last thick Oil, seems to be a production of the fire; for if it were already formed in the mixt, as the other is, it would rise with the same heat, and at the same time, being equally volatile. It is not impossible, however, that it may exist perfectly formed in the plant; but, having contracted an union with some Acid, and therewith composing an Ammoniacal Salt, it may by that means be hindered from rising so readily as is agreeable to its natural volatility.

The Phosphorus obtained by a violent fire, from the *caput mortuum* of this distillation, seems to throw

a light of probability on this conjecture. There is certainly a great deal of Acid in the composition of Phosphorus. Perhaps this Acid was originally combined with our second Volatile Alkali, and formed therewith, as was said, a sort of Sal Ammoniac. Moreover, almost all the plants, that yield a Volatile Alkali by distillation, yield also a considerable quantity of Acid: which may perhaps be the remains of such a Sal Ammoniac decomposed by the operation. This is a subject for curious and useful enquiries. This second Volatile Alkali appears in a concrete form, because very little phlegm comes over along with it; so that the vapours thereof are not sufficient to dissolve it, as they did the first.

C H A P. VII.

OF THE SUBSTANCES OBTAINED FROM VEGETABLES BY COMBUSTION.

P R O C E S S I.

To procure a Fixed Caustic Alkaline Salt from a Vegetable substance, by burning it in the open air.

TAKE any vegetable matter whatever; set it on fire, and let it burn in the open air till it be wholly reduced to ashes. On these ashes pour a quantity of boiling water sufficient to drench them thoroughly. Filter the liquor in order to separate the earthy parts; and evaporate your lye to dryness, stirring it incessantly; and you will have a yellowish-white Salt.

Put this Salt in a crucible; set it in a melting furnace, and make a moderate fire, so as not to fuse

the Salt. It will turn first of a blue-grey colour, afterwards of a blue-green, and at last redish. Put on the dome of the furnace; fill it with coals; make your fire strong enough to melt the Salt, and keep it in fusion for an hour, or an hour and half. Then pour it into a heated metal mortar; pound it while it is red-hot; put it, as soon as possible, into a glass bottle, first made very hot and dry, and shut it up close with a glass stopple rubbed with emery. By this means you will have the pure Fixed Alkali of the vegetable substance you burnt.

OBSERVATIONS.

BURNING a vegetable substance in the open air is a kind of violent and rapid analysis made by fire, which separates, resolves, and decomposes several of its principles.

When any wood or plant is laid on a quick fire, there ascends from it immediately an aqueous smoke, which consists of little more than phlegm; but this smoke soon becomes thicker and blacker: it is then pungent, draws tears from one's eyes, and excites a cough if drawn into the lungs with the breath. These effects arise from its being replete with the Acid, and some of the Oil, of the vegetable converted into vapours. Soon after this the smoke grows exceeding black and thick: it is now still more acrid, and the plant turns black. Its strongest Acid and last thick Oil are now discharged with impetuosity.

This rarefied Oil being heated red-hot suddenly takes fire and flames. The vegetable burns and deflagrates rapidly, till all its Oil is consumed. Then the flame ceases; and nothing remains but a coal, like that found in a retort after all the principles of a plant have been extracted by the force of fire. But this coal having a free communication with the air, which is absolutely necessary to keep a
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combustible burning, continues to be red, sparkles, and wastes till all its phlogiston is dissipated and destroyed. After this nothing remains but the Earth and Fixed Salt of the vegetable; which mixed together form what we call the Ashes. Water, which is the natural solvent of Salts, takes up every thing of that kind that is contained in the ashes; so that by lixiviating them, as directed, all the Salt is extracted, and nothing left but the pure earth of the mixt which is thus decomposed.

The phenomena observed in the burning of a vegetable substance, and the production thereby of a Fixed Alkali, seem to prove that this Salt is the work of the fire; that it did not exist in the plant before it was burnt; that the plant only contained materials adapted to form this Salt; and that this Salt is no other than a combination of some of the Acid, united with a portion of Earth, by means of the igneous motion.

In the first place; a Fixed Alkali may be obtained by lixiviation from the ashes of all vegetable matters that contain an Acid, Earth, and Phlogiston, in due proportion. Thus Essential Salts; the substance of extracts made by trituration, infusion, or decoction; wood coals burnt to ashes; all yield a quantity of this Salt in proportion to the quantity of Acid and Earth contained in them.

Secondly; Fat, Essential, and Empyreumatic Oils afford, when burnt, such a small quantity of Fixed Alkali as is scarce perceptible; because they contain but little Acid, and still less Earth: and these same Oils, when rectified by repeated distillations, and then burnt, leave still less of this Salt; because they are separated by rectification from most of the Acid, together with the small matter of Earth contained in them.

Thirdly; those vegetable matters which being analyzed furnish a great deal of Volatile Alkali,

yield but very little Fixed Alkali; because a great deal of their Acid is employed in forming the Volatile Alkali, which is dissipated by burning the plant: and for the same reason those which in distillation afford only a Volatile Alkali, and no Acid, leave in their ashes little or no Fixed Alkali, as is also the case with animal matters.

Fourthly, and lastly; the ashes of such plants as have been long steeped in water, and from which infusions and decoctions have been made, always contain the less Alkali the longer they have been infused or boiled, and the more water they were infused or boiled in; because water dissolves and carries off their Acid. It is for this reason that the ashes of float-wood are much less saline than those of green wood. Boerhaave assures us, in his Chymistry, that having exhausted Rosemary, by repeated decoctions, and having afterwards boiled the plant thus treated, the ashes produced by it shewed not the least sign of a Fixed Alkali. He says that, in order to exhaust thoroughly all the saline matters contained in Rosemary, he was obliged to decoct it no less than twenty times successively, with fresh water every time, and never ceased boiling it in this manner, till he was sure that the water, by boiling the plant in it for a long time, took up from it no kind of matter whatever that in the least affected its purity: so that the water of his last decoction had absolutely no smell, taste, or colour; but was in short precisely the same as before he used it for the decoction. The same Author observes that his plant, after having been exhausted in this manner, and having suffered such continued boiling, retained nevertheless its perfect external form; that from being green at first it became brown, and sunk to the bottom of the water, instead of floating thereon as it did before decoction.

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If, in reiterating this beautiful experiment of Mr. Boerhaave's, you should not succeed as you expect, you must not therefore accuse this great man of having been mistaken on this occasion; seeing it is very difficult, not to say impossible, to ascertain exactly, from the account he hath given of his experiment, all that is necessary to its perfect success: for he hath not specified either the duration of the coctions which he made the Rosemary undergo, or the quantity of water he employed in each; whereas a difference in either of these may occasion a vast difference in the result. It is evident that if five or six pounds of water be used for each coction of a pound of Rosemary, and be kept boiling for two or three hours, the plant will not be near so much exhausted by being so treated, as if the same quantity thereof were kept boiling for several days in forty or fifty quarts of water.

Indeed, these points seem, in some measure, to be determined, by what he says of the quality which the water of the last decoction ought to have. But the same objections occur here also; nay, the two circumstances of the quantity of water and the duration of the boiling, have the greatest influence here: for the more a plant is exhausted of its Salts, the more difficult it becomes for the water to dissolve and separate the small quantity thereof that remains united with the tenacious Oil; and consequently it may happen that this last water, after the plant hath boiled in it five or six hours, shall appear insipid, scentless, colourless; and yet that a much greater quantity of water, but reduced by longer boiling to the same quantity with that which hath been boiled but five or six hours, shall have acquired both taste and colour; in a word, shew that it hath taken up some of the principles of the plant. It may also happen, that, a small portion of saline matter being diffused through a large quantity of water, after long-con-

tinued coction, shall not be perceptible either to the taste or to the eye; but that the very same portion of saline matter shall become very sensible, when the quantity of water in which it is lost, as it were, is sufficiently lessened by evaporation.

Hence, if we would make sure of fulfilling the conditions required by Mr. Boerhaave, the last decoction of the plant must be made in a much greater quantity of water, and continued for a much longer time, than may perhaps be imagined, or perhaps easily determined; and this decoction being evaporated to any degree you please, must have neither taste, smell, nor colour: in short, it must from first to last remain perfectly like pure water. In other words, it is very difficult to attain to any certainty in this matter.

Though what hath hitherto been said, about procuring the Fixed Alkali of plants by combustion, seems to prove that this Salt is wholly the production of the fire, yet it must not be asserted that no part thereof pre-existed formally in the plant before it was burnt. On the contrary, it is certain that, amongst the saline matters found in the composition of plants, there are true Neutral Salts whose basis is a Fixed Alkali; but this Alkali being combined with an Acid discovers none of its properties, and never appears in its true form till the Neutral Salt of which it makes a part is decomposed by combustion. The case of Sea-plants, all of which contain Sea-salt, and when burnt yield an Alkaline Salt perfectly resembling the basis of Sea-salt, seems to decide this point.

If, in lixiviating the ashes of a plant, to dissolve and wash out its Alkali, you intend that nothing should be left but an absolutely pure earth, fit for making cupels, you must not be contented with one ablution only, even with a large quantity of water; because the ashes continue drenched with the

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the water in which the Salts are dissolved, and consequently, when this water is evaporated, some of the Salts will be left with the earth. Therefore, if this be your view, you must wash it three or four several times, using fresh water every time.

The water impregnated with the Alkali cannot be evaporated without a considerable loss of Salt, especially if it be violently boiled; because the water, with which it is closely united, carries off part of it. In consequence of this intimate union, it is very difficult, when the evaporation is near finished, and but a little water left, to dry the Salt perfectly, because it pertinaciously retains this last portion of humidity.

The Alkali obtained from the ashes of a burnt plant is not perfectly pure; it is contaminated with a small mixture of fatty matters, which were probably defended thereby against the action of the fire, and which render it somewhat saponaceous. In order to free it from this extraneous matter, and to render it very caustic, it must be calcined a long time in a crucible, but without melting it at first: because it is with this Salt as with most metallic matters, which are sooner and more easily deprived of their phlogiston by being calcined without melting, provided they be comminuted into small particles, than when they are in fusion; all melted matters having but a small surface exposed to the air, by the contact of which the evaporation of any thing whatever is exceedingly promoted. It was for this reason we directed the Salt to be calcined for a long time in a crucible before melting it.

Mr. Boerhaave was very sensible of the utility of this calcination of the Alkali previous to its being melted, when in his Chymistry he ordered the ashes containing this Salt to be put into a large earthen vessel, kept red-hot for a considerable time, taking great care that the Salt do not melt. He takes notice,

tice, that, the longer the ashes are calcined in this manner, the stronger is the Alkali obtained from them. This method is, in the main, the very same with that here prescribed, and produces the same effect; because the Alkali is equally well freed of the extraneous fatty matter, whether it be calcined before or after its separation, provided it be not suffered to melt.

Mr. Boerhaave gives another reason for recommending care to be taken that the Fixed Alkali do not melt, while the ashes are calcining to render it stronger and more caustic; for, if that should happen, the melted mixture of the Salt and ashes would produce a vitrified mass, which would have none of the properties of the Salt.

PROCESS II.

To procure the Fixed Salt of a Plant, by burning it after the manner of Tachenius.

IN TO an iron pot put the plant whose Salt you desire to obtain in the manner of Tachenius, and set it over a fire, strong enough to make its bottom red-hot; at the same time cover your plant with a plate of iron, that may lie immediately upon it in the pot. The plant will grow black, and smoke considerably; but will not flame, because it hath not a sufficient communication with the air. The black smoke only will escape through the interstice left between the side of the pot and the rim of the plate; which, for that purpose, should be made so as not to fit exactly into the pot. From time to time take up the iron plate, stir the plant, and cover it again immediately, to prevent its taking fire, or to smother it if it should happen to flame: go on thus till the black smoke cease.

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Then take off the iron plate: the upper part of the half-burnt plant will take fire as soon as the air is admitted, consume gradually, and be reduced to a white ash. Stir your matter with an iron wire, that the undermost parts, which are still black, may be successively brought uppermost, take fire, and burn to white ashes. Go on thus as long as you perceive the least blackness remaining. After this, leave your ashes some time longer on the fire; but stir them frequently, to the end that, if any black particles should still be left, they may be entirely consumed.

Your ashes being thus prepared, lixivate them with seven times their quantity of water, made to simmer over the fire, and keep stirring it with an iron ladle. Then filter the liquor, and evaporate it to dryness in an iron pot, stirring it incessantly towards the end, lest the matter, when it grows stiff, should adhere too closely to the vessel. When all the humidity is evaporated, you will have a Salt of a darkish colour, and alkaline nature; which you may melt in a crucible, and mould into cakes. This is the Fixed Salt of plants, prepared in the manner of Tachenius.

OBSERVATIONS.

THE Fixed Salt obtained from plants in the manner invented by Tachenius, and here described, is in many respects different from the Caustic Fixed Alkali extracted out of the ashes of plants that have been consumed by flaming in the open air. Tachenius's Salt is indeed of an Alkaline nature; but much weaker than a pure Fixed Alkali. It is not by far so caustic; it attracts the moisture of the air much more feebly and slowly; it melts with a much smaller degree of heat; and it doth not make so strong an effervescence with Acids. In short, if you dis-
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solve it in water, evaporate the solution to a pellicle, and set it in a cool place, it will shoot into small crystals; which is not the case with a pure Fixed Alkali.

These several different effects, which characterize Tachenius's Salt, and distinguish it from the Caustic Fixed Alkali produced by burning a plant in the open air, prove that it is not a pure Alkali, but combined with certain substances that bring it nearer to the nature of a Neutral Salt, and place it, as it were, in the mid-way between such a Salt and a true Alkali. If we reflect on the manner in which it is produced, it is easy to perceive what those substances are that must be combined with it. It hath been shewn that plants, when analyzed, yield a great deal of Oil and of Acid. When they are burnt in the open air, all their Oil is dissipated in smoke, or consumed in flame. Great part of the Acid is likewise dissipated, and the remainder combining with the Earth of the plant forms a Fixed Alkali.

When the same plants are analyzed, by distilling them in close vessels, the same principles are carried up by the action of the fire, forced to separate from the fixed parts, and pass over into the receiver in the form of vapours and of a liquid: but, when they are burnt in the manner of Tachenius, the Acid and Oil of the plant, as fast as they are expelled by the action of the fire, are repelled by the iron cover, which, at the same time that it prevents the Oil from being entirely consumed in flame, obliges these two substances to circulate, reverberates them on the rest of the plant, and, in a manner, forces them to re-unite, in part, with that from which they were just before separated.

A considerable quantity, therefore, of the Oil and Acid of the plant, must evidently combine in this operation, with its Fixed Salt, as fast as it is produced; and the properties above specified are
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owing to these two substances. Tachenius's Salt is, therefore, a Fixed Alkali, partly neutralized by some of the Acid of the plant, and rendered a little sapo-naceous by a portion of its Oil; whence it is much milder than a pure Fixed Alkali, and proper to be given internally, as an excellent remedy in several disorders.

For the medicinal virtues of this Salt Mr. Boerhaave's Chymistry ought to be consulted, as the Author was a very good judge of such matters.

Tachenius's Salt may be converted into a Caustic Fixed Alkali, by freeing it from the Acid and from the Oil to which its peculiar properties are owing. For this purpose nothing more is requisite than to calcine it for a long time in a crucible, stirring it frequently with an iron wire, and taking care not to melt it till it have undergone the same changes, and successively acquired the same colours, as our Fixed Alkali; and, when it becomes redish, melting it and keeping it in fusion for an hour or two.

Hitherto no sensible difference hath been observed between the Caustic Fixed Alkalis obtained from different plants, when equally calcined; except that those produced by Sea-plants have, as we said before, the same properties as the Alkaline basis of Sea-salt. Much the same thing may be said of the Fixed Salts obtained from plants by Tachenius's method: for, though they be combined with a portion of the Acid and Oil of the plant, yet, as these principles have been exposed to the action of a strong fire, they are exceedingly altered, and almost wholly reduced to one and the same condition.

PROCESS III.

*To render Fixed Alkalis very caustic by means of Lime.
The Caustic Stone.*

TAKE a lump of newly burnt quick-lime, that hath not yet begun to flake in the air: put it into a stone pan, and cover it with twice its weight of the unwashed ashes of some plants, that are full of the Salt you design to render caustic; Pour on them a great quantity of hot water; let them steep in it five or six hours, and then boil them gently. Filter the liquor through a thick canvass bag, or through brown filtering paper supported by a linen cloth.

Evaporate the filtered liquor in a copper bason set over the fire; and there will remain a Salt, which must be put into a crucible set in the fire. It will melt, and boil for some time; after which it will be still, and look like an Oil, or melted Fat. When it comes to this condition, pour it out on a very hot copper plate, and cut it into oblong tapering slips; before it grow hard by cooling. Put these slips, while they are still hot, into a very dry glass bottle, and seal it hermetically. This is the *Caustic Stone*, or *Common Caustic*.

OBSERVATIONS.

THE design of this operation is to combine with the Fixed Alkali all the saline acrid parts of the quick-lime. This is to be effected only by dispersing and diffusing both those substances in water, which is the proper solvent of all saline matters. Seeing, therefore, we must have an actual lixivium, it is needless to employ an Alkali already prepared and separated from ashes; for which reason we directed ashes that are still replete with Alkali to be used instead of a pure Alkali. By this means two ends are answered at once: the Salt contained in the ashes is extracted from them, and combined with
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the most acrid, subtil, and saline parts of the lime.

The lye, when saturated with these two saline matters together, is vastly more acrid and caustic than if it contained but one of the two in a quantity equal to both. With this lye Soap is usually made; because the acuated Alkali contained in it hath a much greater effect on Oils than any other kind of Alkali. It also acts with incredible violence on all animal matters; which it dissolves, divides, and, in some measure, destroys, with surprising efficacy and quickness.

For this reason it is impossible to filter it through a woollen or silken bag; for it will eat holes in them, or even reduce them to a pap, almost as soon as it touches them. Besides, as the lye would dissolve some part thereof, it would thence acquire a saponaceous quality, and so lose much of its caustic nature. We must, therefore, necessarily use a filter made of vegetable matters, which resist this destroying Salt much better than animal matters.

An Alkali thus acuated by quick-lime attracts and retains humidity more strongly than any other kind of Alkali, even the perfectest and best calcined. For this reason it is almost impossible to dry it thoroughly in the basin wherein you evaporate the lixivium.

To the moisture still left in it must be attributed its boiling when it begins to melt in the crucible. When all the humidity is dissipated, the fused Salt remains smooth and unruffled, like wax melted with a gentle heat.

This caustic Salt is vastly more fusible than the common Alkalis. It scarce grows red before it flows like wax. When it is once in quiet fusion, all the humidity that occasioned the boiling observed at first being dissipated, it is as caustic as it can be made. It is then time to pour it out, and to cut it

into long narrow sticks, fit for the use of Surgeons, who apply it to eat away callosities and excrescences, and to open issues. On this account it is called the *Caustic Stone*. The operation of this Salt is so quick, that, in a very short time, it produces on the skin a sensation like that of fire.

As this Salt grows surprisingly soon moist in the air, and loses its virtue when so moistened, it is necessary to shut it up, while it is still hot, in a very dry bottle, which must be immediately stopped with a glass stopple rubbed with emery, or else with a sound cork and then dipt in pitch. In spite of all these precautions, it can scarce be kept five or six months in full vigour; especially if the bottle be sometimes opened in the mean while. We shall not attempt to explain here why an Alkali becomes so violently caustic by being combined with quicklime. This question seems to be one of the most subtle, and the most difficult to answer, in all Chymistry. It depends on the cause of the Alkaline properties of lime; and can hardly be resolved, till we attain a further insight into the nature of that substance than we have yet got.

PROCESS IV.

The Analysis of Soot.

TAKE wood foot from a chimney under which no animal matter hath been dressed or burnt: put it into a glass retort set in a reverberating furnace: lute on a receiver, and begin to distill with a degree of heat somewhat less than that of boiling water. A considerable quantity of limpid phlegm will come over. Keep the fire in the same degree as long as any of this phlegm rises; but increase it when the drops begin to come slow: and then there will

will ascend a good deal of a milky water. When this water ceases to run, change the receiver, and increase your fire a little: a yellow Volatile Salt will rise, and stick to the sides of the receiver. The fire ought now to be very fierce, and, if so, will force up at the same time a very thick black Oil. Let the vessels cool: you will find a saline matter risen into the neck of the retort, which could not pass over into the receiver: in the bottom of the retort will be a *caput mortuum*, or black charred substance, the upper part of which will be cruusted over with a saline matter, like that in the neck of the retort.

OBSERVATIONS.

THE preceding analyses shewed what principles are obtained from vegetable substances without the aid of fire; those which the heat of fire raises, and carries over out of one close vessel into another; and, lastly, those that continue fixed after the vegetable hath been thoroughly charred, either in a close vessel, or in the open air: nothing therefore remained, to finish the subject of vegetable principles, but to examine those which fire raises, in the form of vapours, smoke, and flame, from a vegetable matter burnt and consumed in the open air. Every body knows that Soot consists only of these principles, collected in the shafts of chimneys, which serve as alembics for this sort of distillation in the open air. By analyzing Wood-Soot, therefore, we shall discover the principles we are in quest of. The process we have given for that purpose is taken from Boerhaave's Chymistry, where we find it described with great exactness and precision.

As we are at present enquiring into the nature of vegetables only, it is evidently necessary that we chuse a Soot produced by burning vegetables alone. Soot, though dry in appearance, contains neverthe-

less much humidity, as appears from this analysis; seeing there comes over at first a considerable quantity of phlegm, that doth not seem to be impregnated with any principle, except perhaps an extremely subtil, saline, and oily matter, that communicates to it a disagreeable smell, from which it cannot by any means be entirely freed.

The white milky liquor, which follows this first phlegm, is still water, but much more impregnated with saline and oily parts than the former. By its smell, which is exceeding quick and pungent, we may judge it contains much Volatile Alkali; and accordingly, when re-distilled by itself, it yields a Volatile Spirit, and a Volatile Salt in a concrete form. With regard to its white colour, it is occasioned by the oily parts which are diffused and suspended, but not dissolved, in the water. When this second liquor is come off, there ascends a Volatile Alkali in a dry form, and a very thick black Oil; because there is not moisture enough left to dissolve these principles, or rather to divide and disperse them.

The Volatile Alkali obtained from Soot is, in a double respect, the product of the fire. In the first place, though it derives its origin wholly from wood, or other vegetables, which, when distilled in close vessels, yield no Volatile Alkali at all, yet it produces such a Salt when analyzed in the present manner: whence it must be inferred that the principles of those vegetables are metamorphosed into a Volatile Alkali, by being burnt in the open air, and sublimed in the form of Soot. Secondly, though Soot when analyzed yields a great deal of this Salt, yet this Salt doth not formally pre-exist therein; for it doth not rise till after the phlegm, nor without a very considerable degree of heat: therefore Soot contains only the materials necessary to form this Salt; therefore the perfect combination of this Salt requires.

requires that the force of fire be applied a second time ; therefore it is, as was said, doubly the product of the fire.

The saline matter, which we find sublimed into the neck of the retort, and which also forms the crust that covers the *caput mortuum* of the Soot, appears by all Chymical trials to be an Ammoniacal Salt ; that is, a Neutral Salt consisting of an Acid and a Volatile Alkali. This Ammoniacal Salt rises only into the neck of the retort, and doth not come over into the receiver ; because it is but semi-volatile. We shall treat more at large of the production of a Volatile Alkali, and of this Ammoniacal Salt, when we come to the analysis of Animals, and the article of Sal Ammoniac.

The charred matter that remains in the retort after distillation, being burnt in the open air, is reduced to an exceeding fixed white earth. As this fixed matter was part of that very Soot, which was sublimed to a great height while the vegetable was burning ; this is a proof of what we advanced before, that the most fixed matters are capable of sublimation, when united with volatile substances ; especially when they are exposed at the same time to the combined action of air and of fire.

C H A P. VIII.

THE ANALYSES OF SOME PARTICULAR SUBSTANCES
BELONGING TO THE VEGETABLE KINGDOM.

P R O C E S S I.

Analysis of the Natural Balsams : instanced in Turpentine.

IN T O a cucurbit put as much rain-water as will fill about a fourth part of its cavity, and pour into it the Turpentine you intend to analyze. Cover the cucurbit with its head, and lute it on with slips of sized paper or wet bladder. Set your alembic in a sand-heat; lute on a long-necked receiver; and give a gradual fire till the water in the cucurbit boil. There will come over into the receiver a good deal of phlegm, which, by little and little, will become more and more acid; and at the same time there will rise a great quantity of an æthereal Oil, extremely light, fluid, and as limpid and colourless as water.

When you observe that no more Oil comes off, unlute your vessels; and in the receiver you will find an acidulated water, and the æthereal Oil floating on it. These two liquors may be easily separated from each other, by means of a glass funnel.

In the cucurbit will be left some of the water you put in, together with the remainder of your Turpentine; which, when cold, instead of being fluid as it was before distillation, will be solid, and of the consistence of a resin, and is then called *Resin*.

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Put this residuum into a glass retort, and distill it in a reverberatory with a naked fire, gradually increased according to the general rule for all distillations. At first, with a degree of heat a little greater than that of boiling water, you will see two liquors come over into the recipient; one of which will be aqueous and acid, the other will be a transparent, limpid, yellowish Oil, floating on the acid liquor.

Continue your distillation, increasing your fire from time to time, by slow degrees. These two liquors will continue to come off together: and the nearer the operation draws to its end, the more acid will the aqueous liquor become, and the thicker and deeper coloured will the Oil grow. At last the Oil will be very thick, and of a deep redish-yellow colour. When nothing more ascends, unlute your vessels: in the retort you will find only a very small quantity of a charred, light, friable substance.

OBSERVATIONS.

ALL Natural Balsams, as well as Turpentine, are oily, aromatic matters, which flow in great quantities from the trees containing them, either spontaneously, or through incisions made on purpose. As these matters have a strong scent, it is not surprising that they should greatly abound with Essential Oils. They may even be considered as Essential Oils, that naturally, and of their own accord, separate from the vegetables in which they exist.

Indeed these Natural Balsams differ from the Essential Oils obtained out of plants by distillation, in this alone, that the former contain a greater proportion of Acid; and, for that reason, are thicker than Essential Oils distilled with the heat of boiling water. But it hath been shewn that these same distilled Essential Oils, though ever so fluid and light

at first, gradually lose their tenuity as they grow old, and at last become considerably thick. On that occasion we observed that they are thus changed, because the lightest, most fluid, and least acid parts are little by little dissipated and evaporated; so that at last there remains only the thickest and heaviest part, which owes these qualities to the Acid where-with it is over-dosed.

Hence it follows that Natural Balsams, and Essential Oils grown thick with age, are exactly one and the same thing. Accordingly we see that fire and distillation produce the same effects on both. The rectification of an Essential Oil, thickened by keeping, is nothing but a decomposition thereof, by separating, with the heat of boiling water, all those parts that are light enough to rise with that degree of heat, from what is so loaded with Acid as to remain fixed therein.

This operation is therefore precisely the same as our first distillation of Balsams with the heat of boiling water, by which the Essential Oil contained in them is drawn off. The residues of these two operations are also the same: each of them is a thick Oil, loaded with Acid, that is wholly, or nearly, deprived of the principle of odour peculiar to the original vegetable, and requires a degree of heat greater than that of boiling water to decompose it, by separating part of the Acid from the Oil; which will be rendered still the more fluid, the more the thickening Acid is separated from it by repeated distillations.

The newer Natural Balsams are, the thinner they are, and the more Essential Oil do they yield; and this Essential Oil, like all others, grows thick in time, and at last turns again to an actual Balsam.

These Balsams, by being long exposed to the heat of the sun, acquire such a consistence as to become solid. They then take another name, and
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are called *Resins*. Resins yield much less Essential Oil when distilled, than Balsams do. Hence it follows that Resins are to Balsams, what Balsams are to Essential Oils. All these effects are produced by the causes assigned above, and confirm the analogy we have established.

We have no other observations to make on this analysis of Turpentine, except that when Resin is distilled in a retort with a naked fire, the operation must be carried on very slowly, and the fire duly governed: for the matter is apt to swell, and to rise in substance into the receiver, without being at all decomposed. In order to avoid this inconvenience, it is adviseable to make use of a long-bodied retort, such as is known by the name of the *English Retort*.

If you stop the distillation of Resin about midway, or when the Oil that comes over begins to grow thick, you may by changing the receiver keep the first Oil apart: it is pretty fluid, and of a middle nature, between the æthereal Oil, obtained with the heat of boiling water, and the last thick Oil, that doth not rise till towards the end of the distillation. This last thick Oil is that which Mr. Homberg fired with concentrated Oil of Vitriol.

If we examine the matter contained in the retort, when the distillation is thus stopped short; it appears, when cold, in the form of a solid substance, almost perfectly diaphanous, of a deep redish-yellow colour, and friable. It is known by the name of *Colophony*.

This analysis of boiled Turpentine, is a specimen of the analysis of almost all other resins; so that what hath been said on this occasion is, in a manner, general, and applicable to other decompositions of the same kind. We shall now proceed to examine some other oily matters, which exhibit peculiar phenomena, and do not come under the general rules.

PROCESS II.

The Analysis of Resins : instanced in Benjamin. The Flowers and Oil of Benjamin.

IN T O a pretty deep earthen pot, having a border or rim round its mouth, put the Benjamin you intend to analyze. Cover the pot with a large conical cap of very thick white paper, and tye it on under the rim. Set your pot in a sand-bath, and warm it gently till the Benjamin melt. Continue the heat in this degree for an hour and a half. Then untie the paper cap and take it off, shaking it as little as possible. You will find all the inside of the cap covered with a great quantity of beautiful, white, shining Flowers, in the form of little needles. Brush them off gently with a feather, put them into a bottle, and stop it close.

As soon as you take off the first cap, cover your pot immediately with a second like the former. In this manner go on till you perceive the Flowers begin to grow yellowish ; and then it is proper to desist.

The matter left in the pot will be blackish and friable when cold. Pulverize it ; mix it with sand : and distill it in a glass retort with a graduated heat. There will come over a light Oil, of a fragrant scent, but in very small quantity ; a little of an acid liquor, and a great quantity of red thick Oil. There will be left in the retort a charred, spongy substance.

OBSERVATIONS.

ALL oily matters, that are naturally thick and in a concrete form, resemble each other in this, that they derive these qualities from an Acid combined with them. But they nevertheless differ greatly from

from one another in many respects. The quality, the quantity, of the Acid to which they owe their consistence, and the manner in which it is united with them, diversify them a thousand ways.

In the preceding process we advanced that Natural Balsams are distinguished from Resins by their containing so much more Oil, in proportion to their Acid, as suffices to render them almost fluid. For this reason they yield an Essential Oil: whereas Resins, on the contrary, are solid; all their Oil being loaded and weighed down with a great quantity of Acid, so that no Essential Oil can be drawn from them.

We observed at the same time, that, when all the Essential Oil contained in a Natural Balsam is drawn off, with the heat of boiling water, the residue takes a solid consistence, and resembles a Resin. In fact almost all Resins yield, by distillation, the same principles as that residue; that is, an Oil of a midling nature between Essential Oils and thick Oils, in point of lightness and fluidity; the whole being always accompanied with an Acid diffused in phlegm.

In consequence hereof the analysis of Benjamin, described in the process, appears to vary very much from that of other Resins: for here we see a volatile matter in a concrete form; namely, the white Flowers that rise first; which doth not usually occur in the analysis of Resins. Yet, if we examine the matter, we shall be convinced that it is very analogous to one of the principles obtainable from all Resins; that indeed it differs therefrom in some of its properties, particularly in its external form; but that it is in reality the very same.

In fact the Flowers of Benjamin are no other than an Oily Acid, nearly of the same nature with those obtained from all other vegetable substances; but which instead of being liquid like them, appears

in a dry concrete form, and in a manner crystallized. It probably derives this property from its Oil being combined with its Acid, either in a greater quantity, or in a more intimate manner, than in the rest, and so strongly united therewith as not to be separated from it by a subliming heat; or from hence, that the compound, of which it is a part, contains too little phlegm to dissolve it; or else, that it is hindered from dissolving therein by the Oil with which it is combined. Perhaps all these causes may concur together in producing its concrete form.

The saline character of this substance appears chiefly from its being soluble in water: but the water must be very hot, and even boiling, before it will effect this solution; and when it cools, the Salt shoots into fine needles at the bottom. This phenomenon directs us to a method of separating it from Benjamin without sublimation.

For this purpose the Resin must be boiled in water: the water will then dissolve the Salt; and, as it cools, the Salt will crystallize, and may be easily collected. But as the Oil, with which the Acid is combined, hinders the water from dissolving it so easily as it otherwise would, we cannot obtain quite so much of it, from the same quantity of Benjamin, by decoction as by sublimation; the last portions thereof being united with a great quantity of Oil, which defends them against the action of the water. This Salt dissolves readily in Spirit of Wine, on account of the Oil combined with it. A course of well connected experiments might give us a far greater insight into its natural properties than we can now boast of.

Benjamin yields a much smaller quantity of fluid Oil by distillation than other Resins do; because the greatest part of its Oil is employed in the composition of its oily, volatile, acid Salt. The thick Oil drawn from this Resin, is thicker than that obtained

tained from any other Resin, and even fixes like butter when cold ; nor can we get more than a very small quantity of Acid in a distinct liquor. All these effects depend on what we mentioned above, in relation to its saline flowers ; to wit, the peculiar and intimate union between the Acid and Oily parts of this Resin, so that the fire cannot so easily or so perfectly disjoin them, as it doth those of other Resins.

Benjamin, when distilled, leaves in the retort much more of a charred coal, than is left by most other resinous matters. This may be owing to the considerable quantity of earthy matter which it contains, and which, perhaps, may also be one of the causes that contribute to give its Salt a concrete form.

REFLECTIONS

ON THE NATURE AND PROPERTIES OF CAMPHOR.

WE do not propose to give an analysis of this singular body ; because hitherto there is no process known in Chymistry by which it can be decomposed. We shall therefore content ourselves with reciting its principal properties, and making a few reflections on its nature.

Camphor is an oily concrete substance ; a kind of Resin, brought to us from the island of Borneo, but chiefly from Japan. This substance resembles Resins, in being inflammable, and burning much as they do ; it is not soluble in water, but dissolves entirely and perfectly in Spirit of Wine ; it is easily separated again from this menstruum, as all other oily matters are, by the addition of water ; it dissolves both in expressed and in distilled Oils ; it hath a very strong aromatic smell. These are the chief properties

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which

which Camphor possesses in common with Resins ; but in other respects, it differs totally from them ; especially in the following particulars.

Camphor takes fire and flames with vastly more ease than any other Resin. It is so very volatile, that it vanishes entirely in the air, without any other heat than that of the atmosphere. In distillation it rises entire, without any decomposition, or even the least alteration. It dissolves in concentrated mineral Acids ; but with circumstances very different from those that attend other Oily or Resinous substances. The dissolution is accompanied with no effervescence, or sensible heat ; and consequently can produce no inflammation. Acids do not burn, blacken, or thicken it, as they do other Oily matters ; on the contrary, it becomes fluid, and runs with them into a liquor that looks like Oil.

Camphor doth not, like other Oily matters, acquire a disposition to dissolve in water by the union it contracts with Acids ; though its union with them seems to be more intimate than that of many Oily matters with the same Acids. On the contrary, if a combination of Camphor and an Acid be diluted with water, these two substances instantly separate from each other : the Acid unites with the water, and the Camphor, being entirely disengaged from it, swims on the surface of the liquor. Neither Volatile Alkalis, nor the most caustic Fixed Alkalis, can be brought into union with it ; for it always eludes their power.

Notwithstanding these wide differences between Camphor and all other Oily and Resinous substances, the rule, that Acids thicken Oils, seems to be so universal, and so constantly observed by nature, that we cannot help thinking this substance, like all the rest, is an Oil thickened by an Acid. But what Oil ? What Acid ? and how are they united ? This is a subject for very curious enquiries.

With

With a yellow Oil drawn from wine, and an acid vinous Spirit, of which we shall say more under the article of *Æther*, Mr. Hellot made a kind of artificial Camphor; a substance having the odour, flavour, and inflammability of Camphor; an imperfect Camphor. True Camphor hath the levity, the volatility, and the inflammability of *Æther*. Can it be a substance of the same nature with *Æther*, a kind of solid *Æther*, an *Æther* in a concrete form?

P R O C E S S III.

The Analysis of Bitumens: instanced in Amber. The Volatile Salt and Oil of Amber.

INTO a glass retort put some small bits of Amber, so as to fill but two thirds of the vessel. Set your retort in a furnace covered with its dome; fit on a large glass receiver; and, beginning with a very gentle heat, distill with degrees of fire. Some phlegm will first come off, which will gradually grow more acid, and be succeeded by a Volatile Salt, figured like fine needles, that will stick to the sides of the receiver.

Keep the fire up to this degree, in order to drive over all the Salt. When you perceive that little or none rises, change the receiver, and increase your fire a little. A light, clear, limpid Oil will ascend. As the distillation advances, this Oil will grow higher coloured, less limpid, and thicker, till at last it will be opaque, black, and have the consistence of Turpentine.

When you perceive that nothing more comes off, though the retort be red-hot let the fire go out. You will have in the retort a black, light, spongy coal. If you have taken care to shift the receiver, from time to time, during the distillation of your
Oil,

Oil, you will have sundry separate portions thereof, each of which will have a different degree of tenuity or thickness, according as it came over at the beginning, or towards the end of the distillation.

OBSERVATIONS.

THE substance of which we have here given the analysis, together with all others of the same, that is, of the Bituminous kind, is by most Chymists and Naturalists classed with Minerals; and so far they are right, that we actually get these mixts, like other minerals, out of the bowels of the earth, and never procure them immediately from any vegetable or animal compound. Yet we have our reasons for proceeding otherwise, and for thinking that we could not, in this work, place them better, than immediately after those vegetable substances which we call Resins.

Several motives determine us to act in this manner. The analysis of Bitumens demonstrates, that, with regard to the principles of which they consist, they are totally different from every other kind of mineral; and that, on the contrary, they greatly resemble vegetable Resins in almost every respect. In short, though they are not immediately procured from vegetables, there is the greatest reason for believing that they were originally of the vegetable kingdom, and that they are no other than resinous and oily parts of trees or plants, which by lying long in the earth, and there contracting an union with the mineral Acids, have acquired the qualities that distinguish them from Resins.

Mineralogists know very well that we find, every where in the earth, many vegetable substances, that have lain very long buried under it, and frequently at a considerable depth. It is not uncommon to find, under ground, vast beds of fossile trees, which seem

to be the remains of immense forests: and Bitumens, particularly Amber, are often found among this subterraneous wood.

These considerations, joined to proofs drawn from their analysis, make this opinion more than probable: nor are we singular in maintaining it, as it is adopted by many able modern Chymists.

The analysis of Amber, above described, may serve as a general specimen of the decomposition of other Bitumens: with this single difference, that Amber is the only one among them which yields the Volatile Salt aforesaid; and this determined us to examine it preferably to any other. As for the rest, they all yield a phlegm, an acid liquor, and an Oil; which is thin at first, but grows thicker and thicker, as the distillation draws towards an end. It must be understood, however, that these Acids and these Oils may differ, according to the nature of the Bitumens from which they are drawn; just as the Phlegm, the Acid, and the Oil, resulting from the decomposition of Resins, differ in quantity and quality, according to the nature of the Resins from which they are procured.

The principal differences observed between Resins and Bitumens are these: the latter are less soluble in Spirit of Wine; have a peculiar scent, which cannot be accurately described, and of which the sense of smelling only can judge; and their Acid is stronger and more fixed. This last property is one of the motives which induce us to think, that, besides the vegetable Acid, originally combined with the Resinous or Oily matter now become a Bitumen, a certain quantity of mineral Acid hath, in a course of time, been superadded to constitute this mixt. We shall presently see that the fact is certainly so, in the case of Amber at least.

Almost

Almost all Authors, who mention the analysis of Amber, have given different accounts of the Volatility of its Salt, and of the time of the distillation when it begins to rise. Some make it ascend immediately after the first acid phlegm. Others say that it doth not begin to appear till after the first thin Oil; and others again affirm that it comes over with the last thick Oil. Mr. Bourdelin, who hath examined this matter to the bottom, in a Memoir on the analysis of Amber given in to the Academy, very judiciously remarks, that the different results, which those Chymists met with in analyzing our mixt, arose wholly from the different manner wherein each conducted his fire during the operation.

It is certain that such a cause is capable of producing vast differences: for when fire is hastily applied, or made too violent, it not only confounds and tumultuously mingles the principles of the body to be analyzed, but it even frequently drives up the entire substance itself out of the retort into the receiver, without decomposing it at all. This is really so in the case of Amber, and of almost all compound substances that are not extremely fixed.

It ought therefore to be observed, as a general and important rule in every analysis, to administer the fire exceeding slowly and cautiously, as one can never err on that side; and to increase it only by such degrees as appear necessary for carrying on the distillation. By observing this method, an accurate analysis will be attained: by this means the Salt of Amber will rise before the Oil: whereas, if a degree of heat sufficient to raise the thin Oil, or even the thick Oil, be applied at first, the Salt will accordingly come over with the one or the other of these Oils.

Chymists remained a long time unacquainted with the nature of this Salt of Amber, and Authors of the greatest name agreed as little on this point, as

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on that just mentioned. Some asserted it to be a Volatile Salt of the same kind with that which is obtained from animal substances; that is, a Volatile Alkali: others, on the contrary, pretended that it was an Acid of a singular nature.

It is very surprising that such Authors should disagree on such a point; considering how easily it may be ascertained whether this Salt be really an Acid or an Alkali. Mr. Bourdelin justly decides the question in favour of those who affirm it to be an Acid. In fact it hath all the properties of an Acid: it hath the taste of one, forms Neutral Salts with Alkalis, and differs from the most unquestionable Acids in this alone, that, being combined with a portion of Oil and a small quantity of earth, these give it a concrete form; which is not a solitary case in Chymistry, as is evident from Cream of Tartar. With regard to its Volatility, there is nothing in that repugnant to the properties of its constituent principles; seeing the Acid and the Oil predominant therein may easily be supposed to communicate their Volatile nature to the small portion of earth with which they are combined.

Those Chymists, who looked upon the Salt of Amber as a Volatile Alkali, either did not examine it thoroughly, but contented themselves with its first appearance, in which it resembles the Volatile Salt of animals, or else were led into the error by some particular circumstances. We know, for example, that animal as well as vegetable substances are dug out of the earth. The insects, sometimes found inclosed in lumps of Amber, sufficiently prove this. Perhaps they made their experiments on such pieces of Amber; or else, that which they used might be mixed with some animal substance not very perceptible. In such a case it would be no wonder if the Volatile Salt obtained should shew some tokens of an Alkali: for the Volatile

Alkali arising from the animal matter would only be mixed, not combined, with the Salt of the Amber; as the great quantity of Oil, in which both these Salts are intangled, would hinder them from dissolving each other, and forming such a Neutral Salt as would be produced in other circumstances.

The acid or alkaline nature of the Salt of Amber was not the only point that remained to be discussed on this occasion. Its acid quality being once clearly ascertained, the nature of this Acid was next to be determined. This is the object chiefly aimed at in Mr. Bourdelin's Memoirs, and his discovery thereof is unquestionably one of the finest, and at the same time one of the most difficult, that could be attempted with regard to this Bitumen.

It appears plainly from several experiments, of which we have given an account in the course of this work, that the strongest mineral Acids, by being combined with any Oily matter, are so vastly altered, and so strangely disguised, that we not only are incapable of distinguishing what they are, but even can hardly avoid decomposing, and partly destroying them, by those very operations which seem the best adapted to separate them from the Oil in which they are inviscated. Mr. Bourdelin had all these difficulties to surmount, and incessantly met with new obstacles in that troublesome fatty matter, which, like an impenetrable veil, concealed from his view the Acid whose nature he wanted to discover. But at last, by dint of manifold experiments, he happily gained his end. Two parts of pure Nitre, unadulterated with the least particle of Sea-Salt, and one part of Amber, pulverized and mingled together, procured him, by deflagration, a Salt partly neutral and partly alkaline; which being lixiviated, and set to evaporate spontaneously, there formed at the bottom a residue of a mucilaginous

ginous, pappy, whitish matter, amongst which he could distinguish crystals, that were very transparent, regularly figured, of a cubical form, but rather oblong; so that they represented little oblong squares most exactly formed, and about half a line thick.

As these crystals perfectly resembled, in their figure, the Neutral Salt produced by a combination of the Acid of Sea-salt with the Alkaline basis of Nitre; this was a proof to Mr. Bourdelin that the Acid of Amber is of the same kind, or rather exactly the same, with that of Sea-salt. The Nitre being alkalized by means of the phlogiston of the Amber, the Acid of the Bitumen, finding this Alkali a proper basis to fix in, unites with it, and by that means is enabled to resist the action of the fire, so as not to be carried off by it.

On the other hand, it is separated from the fat matter by which it was masked before; for by the help of this fat matter the Nitre is alkalized. The Acid, having by this means recovered all its properties, begins to discover them, as hath been said, by the figure it constantly gives to the crystals of the Neutral Salt which it helps to constitute.

Moreover, this Neutral Salt hath all the essential properties of Sea-salt. It hath its taste; it decrepitates in the same manner on live coals; if Oil of Vitriol be poured on it, white vapours arise, which have the smell of Spirit of Salt, and are an actual Spirit of Salt. Lastly, it makes a white precipitate of Mercury dissolved in Spirit of Nitre, and a *luna cornea* of Silver dissolved in the same Spirit; which last proofs would alone be sufficient to establish Mr. Bourdelin's opinion, though we had no other.

It were to be wished that the experiments which Mr. Bourdelin hath made on Amber were also tried on other Bitumens. There is reason to think

they would be found to contain either the Marine or the Vitriolic Acid : for though they do not yield a Volatile Salt, as Amber doth, in distillation, yet the Acids obtained from them are very strong, and appear, as we said before, to have a mineral origin. Mr. Geoffroy observed that Amber being pulverized and infused in hot water, parts with its Salt in the same manner as Benjamin does ; which gives room to suspect that Amber is to Bitumens what Benjamin is to Resins.

P R O C E S S I V.

The Analysis of Bee's-Wax, and such Oily Compounds as are analogous to it.

MELT the Wax you intend to analyze, and mix with it as much fine sand as will make it into stiff paste. Put this paste in little bits into a retort, and distill as usual, with a graduated fire, beginning with a very gentle heat. An acid phlegm will come over, and be followed by a liquor which at first will look like an Oil, but will soon congeal in the receiver, and have the appearance of a butter or grease. Continue the distillation, increasing the fire by insensible degrees, till nothing more will come off. Then separate the butter from the acid phlegm in the receiver, mix it with fresh sand, and distill it again just as you did the Wax before. Some acid phlegm will still come off, and an Oil will ascend, which will not fix in the receiver, though it be still thick. Continue the distillation with a fire so governed that the drops may succeed each other at the distance of six or seven seconds of time. Do not increase it, till you perceive the drops fall more slowly ; and then increase it no more than is necessary

fary to make the drops follow each other as above directed. When the distillation is finished, you will find in the receiver the Oil come wholly over, and a little acid phlegm. Separate the Oil from this liquor; and, if you desire to have it more fluid, re-distill it a third time in the same manner.

OBSERVATIONS.

BEE'S-WAX, like all other oily matters in a concrete form, is an Oil thickened by an Acid. Its decomposition furnishes us with a very convincing proof of this truth; which, you see, is confirmed more and more, by every new analysis we make of such substances.

Wax doth not part with all its Acid in the first distillation: and this is the reason that it doth not then become a fluid oil, but a butter, which hath only a degree of softness proportioned to the quantity of Acid separated from it. The same thing holds with regard to its butter; which losing, by a second distillation, a great part of the remaining Acid which caused its consistence, is by that means turned to an Oil. Lastly, this Oil, from being thick, becomes very fluid by a third distillation, and so follows the general rule of Oils; which always become the more fluid the oftener they are distilled or rectified.

What is here said concerning Wax is applicable to Resins also; which it further resembles in its consistence, and its refusing to dissolve in water: yet it differs from them essentially in several respects; and for this reason we thought proper to treat of it in particular. The properties in which it differs from Resins are these:

First, it hath no aromatic scent, nor acrid taste, as Resins have.

Secondly, it doth not yield a thin limpid Oil in the first distillation, as they do.

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Thirdly,

Thirdly, its Oil, or its butter, doth not grow sensibly thicker with age. Mr. Boerhaave kept some butter of Bee's-Wax for twenty years, in a vessel that was not stoppt, but only covered with a bit of paper; yet it did not grow hard. An Essential Oil, though kept much closer shut up, would in much less time have acquired the consistence of a Balsam; and a Balsam, in that time, would have become a Resin.

Fourthly, Bee's-Wax is not soluble in Spirit of Wine; whereas it is the very nature of Resins to dissolve in that menstruum.

Fifthly, I have observed that Spirit of Wine acts faintly on the butter of Bee's-Wax; dissolves that butter when distilled to an Oil; unites more readily with that Oil when rectified by a third distillation; and dissolves it still the more readily the oftener it is distilled. Resins, on the contrary, are more soluble in Spirit of Wine than the thin Oils drawn from them; and those Oils acquire the property of resisting that menstruum more and more obstinately the oftener they are rectified.

By these differences we may judge whether it be proper to confound Bee's-Wax with Resins, or whether it ought not rather to be considered as an oily compound of a singular species, which deserves to be ranked in a different class, or at least in some other division.

If we take the most cursory view of the properties of Essential Oils, and compare them with those of Fat Oils, we cannot avoid being struck with a resemblance between the properties of Essential Oils and those of Resins, as well as with the apparent conformity between the properties of Fat Oils and those of Bee's-Wax: from all which we may conclude with good reason, in my opinion, that the Oil of Bee's-Wax is not of the same nature with that of Resins. The Oil of Resins hath all the properties of
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an Essential Oil, and is justly allowed to be an Essential Oil rendered thick and ponderous by an Acid. The Oil of Bee's-Wax, on the contrary, hath all the properties of Fat Oils; and there is great room to think that this substance is really no other than a Fat Oil hardened by an Acid.

Bee's-Wax is not the only oily compound that appears to have a Fat Oil for its basis. Certain shrubs in America yield, by decoction, a substance that hath all the properties of Bee's-Wax, differing therefrom only in its colour, which is green. The Butter of Cacao is also a substance analogous to Bee's-Wax, and would be really Wax, if it were but as hard; for it contains the same principles, but in different proportions: in short, it is to Bee's-Wax what Balsams are to Resins.

P R O C E S S V.

The Saccharine Juices of Plants analyzed: instanced in Honey.

PUT into a stone cucurbite the Honey you intend to distill; set it in a moderate sand-heat, and evaporate the greatest part of its humidity, till you perceive the phlegm begin to be acid. Then take out the matter remaining in the cucurbite, put it into a retort, leaving a full third thereof empty, and distill in a reverberatory with degrees of fire. An acid, amber-coloured liquor will come over. As the operation advances this liquor will continually become deeper coloured and more acid, and at the same time a little black Oil will ascend. When the distillation is over, you will find in the retort a pretty large charred mass, which being burnt in the open air, and lixiviated, affords a Fixed Alkali.

OBSERVATIONS.

IF we consider nothing but the nature of the principles obtained from Honey, we may be induced to think that this substance is of the same kind with Resins: for we get from each a Phlegm, an Acid, an Oil, and a Coal. Yet there is a very great difference between these two sorts of compounds. Oily matters of the resinous kind are very inflammable, and by no means soluble in water: Honey, on the contrary, is not inflammable in its natural state; will not flame till it be half consumed, or turned almost to a coal, by the fire; and mixes readily and perfectly with water. Now whence can this difference arise? Since it is not owing to the nature of the principles that constitute these mixts, it must necessarily be attributed to the proportions in which those principles are united. And indeed, if we attend to the quantities obtained from each by analyzing them severally, we shall find that, in this respect, there is a very great difference between them. Oily compounds of the nature of Resins, which are not soluble in water, yield in distillation a little phlegm, a quantity of Oil vastly exceeding that of their Acid, and a very small matter of coal, which, when burnt, scarce leaves any token of a Fixed Alkali. Honey, on the contrary, and all other juices of the same nature, give out, when analyzed, a great deal of phlegm, a quantity of Acid much superior to that of their Oil, and a considerable mass of coal; from which, when burnt in the open air and lixiviated, a very perceptible Alkali may be obtained.

If the quantity of the principles procured by these two analyses be compared together, it will be easy to deduce from thence the causes of the different properties observed in the mixts that afforded them. In the large quantity of Oil, of which resinous substances

stances consist almost entirely, we see the cause of their being so inflammable, and so indissoluble in water. When such bodies are decomposed, there remains but little coal, and very little Fixed Alkali; because their Oil carries off with it almost all their Acid, leaving a scarce perceptible portion thereof fixed in the coal. Now we know that this Acid is an essential requisite to the formation of an Alkali. Honey, on the contrary, and the analogous mixts, are so unapt to take fire, and mix so readily with water, only because there is very little Oil in their composition, in comparison of the Acid, which is their predominant principle. For the same reason they leave, when decomposed, a greater quantity of coal, which also yields much more Fixed Alkali than we find in the coals of Resins. Perhaps these mixts may also contain a little more earth. The cause of this greater quantity of Fixed Alkali will be found in what we delivered above concerning the combination and production of that Salt.

Sugar, Manna, and the Saccharine juices of fruits and plants, are of the same nature as Honey, yield the same principles, and in the same proportions. All these substances must be considered as Native Soaps; because they consist of an Oil rendered miscible with water, by means of a saline substance. They differ from the common Artificial Soaps in several respects; but chiefly in this, that their saline part is an Acid, whereas that of common Soap is an Alkali. The natural Soaps are not for that reason the less perfect: on the contrary, they dissolve in water without destroying its transparency, and without giving it a milky colour; which proves that Acids are not less proper than Alkalis, or rather that they are more proper additaments, for bringing Oils into a saponaceous state.

But it must be owned that we are not yet able to imitate by art the Acid Soaps which are prepared
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and so perfectly combined by nature, and that the deterfive quality of these is not near so strong as that of the Soaps which have an Alkali for their saline principles.

Though Honey, and the other vegetable substances analogous to it, contain much Acid, yet they have no taste of sourness, nor any of the other properties of Acids; but on the contrary their taste is soft and saccharine: the cause of this is that their Acid is intimately mixed and perfectly combined with their Oil, which entirely sheathes and blunts it:

P. R O C E S S VI:

Gummy Substances analyzed: instanced in Gum Arabic.

DISTILL Gum Arabic in a retort with degrees of fire. A limpid, scentless, and tasteless phlegm will first come over; and then a ruffet-coloured acid liquor, a little Volatile Alkali, and an Oil, which will first be thin and afterwards come thick. In the retort will be left a good deal of a charred substance, which being burnt and lixiviated will give a Fixed Alkali.

O B S E R V A T I O N S.

Gums have at first sight some resemblance of Resins; which hath occasioned many resinous matters to be called Gums, though very improperly: for they are two distinct sorts of substances, of natures absolutely different from each other. It hath been shewn that Resins have an aromatic odour; that they are indissoluble in water, and soluble in Spirit of Wine; that they are only an Essential Oil grown thick. Gums, on the contrary, have no odour, are soluble in water, indissoluble in Spirit of Wine, and, by being analyzed as in the process, are converted almost

almost wholly into a phlegm and an Acid. The small portion of Oil contained in them is so thoroughly united with their Acid, that it dissolves perfectly in water, and the solution is clear and limpid. In this respect Gums resemble Honey, and the other vegetable juices analogous to it. They are all fluid originally; that is, when they begin to ooze out of their trees. At that time they perfectly resemble mucilages, or rather they are actual mucilages, which grow thick and hard in time by the evaporation of a great part of their moisture: just as Resins are true Oils, which, losing their most fluid parts by evaporation, at last become solid. Infusions, or slight decoctions of mucilaginous plants, when evaporated to dryness, become actual Gums.

Some trees abound both in Oil and in mucilage: these two substances often mix and flow from the tree blended together. Thus they both grow dry and hard together in one mass, which of course is at the same time both gummy and resinous: and accordingly such mixts are named Gum-Resins.

But it must be observed that these resinous and gummy parts suffer no alteration by being thus mixed: but each preserves its properties, as if it were alone. The reason is, that they are not truly united together: Gums being indissoluble by Oils or by Resins, the parts of each are only entangled among those of the other, by means of their viscosity. Hence, if the Gum-Resin be put into water, the water will dissolve only the gummy part, without touching the resinous. On the contrary, if the same Gum-Resin be put into Spirit of Wine, this menstruum will dissolve the Resin, and leave the Gum. We shall treat more particularly of this dissolution under the head of Spirit of Wine.

If a Gum-Resin, instead of being only infused in water, be triturated with water; it will be thereby wholly diffused through it; but the resinous part,

which is only divided by the triture, and not dissolved in the water, gives the liquor a milky colour, like that of an emulsion. It is indeed an actual emulsion; that which is made with kernels being, like this, no other than a divided Oil, dispersed in small particles by triture, and suspended in the water by means of a mucilage.

SECTION II.

Of Operations on Fermented Vegetable Substances.

CHAP. I.

OF THE PRODUCT OF SPIRITUOUS FERMENTATION.

PROCESS I.

To make Wine of Vegetable Substances that are susceptible of Spirituous Fermentation.

LET a liquor susceptible of, and prepared for, the Spirituous Fermentation be put into a cask. Set this cask in a temperately warm cellar, and cover the bung-hole with a bit of linen cloth only. In more or less time, according to the nature of the liquor to be fermented, and to the degree of heat in the air, the liquor will begin to swell, and be rarefied. There will arise an intestine motion, attended with a small hissing and effervescence, throwing up bubbles to the surface, and discharging vapours; while the gross, viscous, and thick parts, being driven up by the fermenting motion, and rendered lighter by little bubbles of air adhering to them, will

will rise to the top, and there form a kind of soft spungy crust, which will cover the liquor all over. The fermenting motion still continuing, this crust will, from time to time, be lifted up and cracked by vapours making their escape through it; but those fissures will presently close again, till, the fermentation gradually going off, and at last entirely ceasing, the crust will fall in pieces to the bottom of the liquor, which will insensibly grow clear. Then stop the cask close with its bung, and set it in a cooler place.

OBSERVATIONS.

MATTERS that are susceptible of the Spirituous Fermentation are seldom so perfectly prepared for it by nature as they require to be. If we except the juices that flow naturally from certain trees, but oftener from incisions made on purpose in them, all other substances require some previous preparation.

Boerhaave, who hath handled this subject excellently well in his Chymistry, divides the substances that are fit for Spirituous Fermentation into five classes. In the first he places all the mealy seeds, the legumens, and the kernels of almost all fruits. The second class includes the juices of all fruits that do not tend to putrefaction. In the third class stand the juices of all the parts of plants which tend rather to Acidity than to putrefaction; and consequently those which yield much Volatile Alkali are to be excluded. The fourth class comprehends the juices or saps that spontaneously distill from several trees and plants, or flow from them when wounded. He forms his fifth and last class of the saponaceous, saccharine, and concrete or thick juices of vegetables. Resinous or purely gummy matters are excluded, as not being fermentable.

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These five classes may be reduced to two; one comprehending all the Juices, and another all the Mealy parts, of vegetables that are susceptible of fermentation. The juices want nothing to fit them for fermentation, but to be expressed out of the substances containing them, and to be diluted with a sufficient quantity of water. If they be very thick, the best way is to add so much water as shall render the mixed liquor just capable of bearing a new-laid egg. With respect to farinaceous substances, as they are almost all either oily or mucilaginous, they require a little more management. The method of brewing malt-liquors will furnish us with examples of such management. It is thus described by Mr. Boerhaave.

In warm weather the grain is put into large vats, and a considerable quantity of rain-water, or very clean river-water, is poured thereon, in which it lies till it be well soaked and swelled. This first operation is called the *Steeping*.

When the grain is by this means grown very plump, it is taken out of the steep, and laid on great heaps in an open place, yet not too much exposed to the wind. In a very little time those heaps grow hot, the grain begins to sprout, and shoot out little buds of leaves and roots. The art of managing this operation properly consists in seizing the exact point of time when the germination should be stopt: on this in a great measure depends the success of the business. For, if the grain be left too long in this hot bed, it may begin to rot, or else the leaves and roots, by growing too much, may consume most of the mealy substance, which, in this case, is the only subject of fermentation; and, if the germination be checked too soon, the advantage expected from it will be lost; that is, the mucid matters will not be sufficiently attenuated.

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As soon therefore as the germination is observed to have attained its proper stage, it must be stopt with all possible expedition. For this purpose the grain is carried into an open place exposed to the north wind, where it is spread on a boarded floor and dried; by which means it is hindered from sprouting any more. It is next made to run slowly down through a long tunnel made very hot, which at once dries it thoroughly to the very heart, and in some measure scorches it, though very slightly. Grain thus prepared is called *Malt*.

By this germination, exsiccation, and slight torrefaction of the grain, the farinaceous substance is considerably attenuated, and its natural viscosity destroyed, which would otherwise hinder the meal, when boiled in water, from mixing with it and dissolving in it, as it must in some measure do to form a liquor fit for Spirituous Fermentation.

Mr. Boerhaave takes notice that if grain, which hath not been thus prepared, be chewed in the mouth, its meal makes a paste that is not easily attenuated, or entirely dissolved, by the spittle; whereas the meal of the same grain, after malting, mixes immediately and perfectly with the spittle: it hath moreover a sweet agreeable taste, which common grain hath not.

The grain being thus malted is ground: then hot water is poured thereon, in which it is left to infuse for three or four hours. In that time the water takes up all the attenuated flour of the Malt; whereas it would not dissolve the farina of grain that had not undergone the above described preparations. The Wort is then drawn off the grains, and boiled to a proper degree of inspissation; the decoction is suffered to cool, and afterwards put into casks to be fermented as the process directs.

As Malt-liquor is apt to grow sour, and will not keep so long as Wine, some bitter plants are usually
boiled

boiled in the decoction, to make it keep the longer, and hinder it from turning sour so soon as it otherwise would. For this purpose such plants are chosen as have an agreeable bitter taste; and the preference is generally given to Hops.

Besides these preparations, relating chiefly to Malt-liquors, there are many other things to be observed relating to Spirituous Fermentation in general, and to all matters susceptible of that fermentation. For example; all grains and fruits designed for that fermentation must be perfectly ripe; for otherways they will not ferment without difficulty, and will produce little or no inflammable Spirit. Such matters as are too austere, too acrid, or astringent, are for the same reason unfit for Spirituous Fermentation; as well as those which abound too much in Oil.

In order to make the fermentation succeed perfectly, so as to produce the best Wine that the fermented liquor is capable of affording, it is necessary to let it stand quiet without stirring it, lest the crust that forms on its surface should be broken to little fragments, and mix with the liquor. This crust is a kind of cover, which hinders the spirituous parts from exhaling as fast as they are formed. The free access of the air is another condition necessary to fermentation: and for this reason the vessel that contains the fermenting liquor must not be close stopped; the bung-hole is only to be covered with a linen cloth, to hinder dirt and insects from falling into it. Nor must the bung-hole be too large, lest too much of the spirituous parts should escape and be lost.

Lastly, a just degree of warmth is one of the conditions most necessary for fermentation: for in very cold weather there is no fermentation at all; and too much heat precipitates it in such a manner
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that the whole liquor becomes turbid, and many fermenting and fermented particles are dissipated.

If, notwithstanding the exactest observance of every particular requisite to excite a successful fermentation, the liquor cannot, without difficulty, be brought to effervesce, which scarce ever happens, but to Malt-liquor, it may be accelerated by mixing therewith some matter that is very susceptible of fermentation, or actually fermenting. Such matters are called *Ferments*. The crust, or *Yeast*, that forms on the surface of fermenting liquors is a most efficacious ferment, and on that account very much used.

It sometimes happens that there is occasion to check the fermentation excited in the liquor, before it ceases of itself. To effect this, such means must be used as are directly opposite to those mentioned above for promoting fermentation. The end is obtained by mixing with the liquor a quantity of Alkali, sufficient to absorb the Acid contained therein: but this method is seldom made use of, because it spoils the liquor; which after being thus treated, is incapable of any spirituous fermentation, but on the contrary will certainly putrefy.

Spirituous fermentation may also be stopped by mixing with the liquor a great quantity of some mineral Acid. But this likewise alters its nature; because these Acids, being fixed, always remain confounded therewith, and never separate from it.

The best method yet found out for checking this fermentation, without injury to the fermenting liquor, is to impregnate it with the fumes of burning sulphur. These fumes are known to be acid, and it is that quality in them which suspends the fermentation. But at the same time this Acid is extremely volatile: so that it separates spontaneously from the liquor, after some time, and leaves it in a condition to continue its fermentation.

For this reason when a Wine is desired that shall be but half fermented, and shall partly retain the sweet taste it had in the state of *Must*, (the proper name for the unfermented juice of the grape) it is put into casks in which Sulphur hath been previously burnt, and the vapours thereof confined by stopping the bung-hole. These are called *Matched Wines*. If the same operation be performed on Must, its fermentation will be absolutely prevented: it will retain all its saccharine taste, and is then called *Stum*. As the sulphureous Acid evaporates spontaneously, in no long space, it is necessary to fumigate matched wines or stums from time to time, when they are intended to be kept long without fermenting.

PROCESS II.

To draw an Ardent Spirit from Substances that have undergone the Spirituous Fermentation. The analysis of Wine.

FILL a large copper cucurbite half full of Wine. Fit on its head and refrigeratory. Lute on a receiver with wet bladder, and distill with a gentle fire; yet so that the drops which fall from the nose of the Alembic may succeed one another pretty quick, and form a sort of small continued stream. Go on thus till you perceive that the liquor which comes over ceases to be inflammable; and then desist. You will find in the receiver a clear liquor, somewhat inclining to an amber-colour, of a pleasant quick smell, and which being thrown into the fire instantly flames. The quantity thereof will be nearly a fourth part of the Wine you put into the alembic; and this is what is called *Brandy*; that is, the Ardent Spirit of Wine loaded with much phlegm.

In order to rectify it, and reduce it to Spirit of Wine, put it into a long-necked matrafs, capable of holding double the quantity. Fit a head to the matrafs, and lute on a receiver: place your matrafs over a pot half-full of water; set this pot over a moderate fire; and with this vapour-bath distill your Spirit, which will rise pure. Continue this degree of heat till nothing more will come over. You will find in the receiver a very clear colourless Spirit of Wine, of a quick but agreeable smell, which will catch fire at once by the bare contact of any flaming substance.

OBSERVATIONS.

It hath been shewn that Honey, and the vegetable juices analogous to it, such as Must, and the juices of all saccharine fruits and plants, yield by distillation no other principles than phlegm, an Acid, and a small quantity of Oil. The analysis of Wine, and of all substances that have undergone the spirituous fermentation, shews us that this fermentation produces, and in some sense creates, in those mixts, a principle that did not exist in them before; I mean the Ardent Spirit, which is an inflammable liquor that is miscible with water. This liquor results from a closer combination of the Acid and the Oil, which are attenuated and united together by fermentation. To this Oil, which is one of its constituent parts, its inflammability is owing; and the Acid imparts to this Oil the property of mixing with water, more perfectly and more intimately than when it makes a part of any other compound. Nay, there is, in the very composition of an Ardent Spirit, a certain quantity of water which is necessary to it, which is one of its essential parts, and without which it would not have the properties that characterise it. We shall presently have occasion to see, that, when Spirit of Wine is dephlegmated to a certain pitch, we cannot

deprive it of any more of its aqueous parts, without decomposing a quantity of the Spirit, proportioned to the quantity of water drawn from it.

Ardent Spirits are more volatile than any of the principles of the mixt from which they are produced, and consequently more volatile than the phlegm, the Acid, or the Oil thereof, though they wholly consist of these. This cannot be attributed to any thing but a peculiar disposition of these principles, which are attenuated in a singular manner by the fermenting motion, and thereby rendered more susceptible of expansion and rarefaction.

The great volatility of the Ardent Spirit procures us an easy method of separating it from the other principles of Wine, and of dephlegmating it. For this purpose it need only be distilled with such a gentle heat as is just capable of raising the Spirit, but too weak to produce the same effect on the other matters from which you desire to free it. For this reason the more slowly, and with the less heat, you distill your Wine, the stronger and more spirituous will your Brandy be. The same is to be said of the second distillation, by which Brandy is changed into Spirit of Wine; or, in other words, dephlegmated. The Spirit of Wine thus drawn from it will be so much the better, the more exactly you observe the conditions here proposed.

If Spirit of Wine be treated in the same manner as Brandy, that is, if it be rectified by distillation with the same precautions, it will be thereby dephlegmated as much as possible; and then it is called *Alkohol*. By this rectification it is not only freed from its redundant phlegm, but also from some particles of Acid, and of Oil, which, though much less volatile than itself, yet ascend with it in the first distillation: nor is it possible wholly to avoid this inconvenience.

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Mr. Boerhaave proposes to dephlegmate Spirit of Wine more easily, and more accurately, by distilling it from decrepitated Sea-salt mixt, while very hot, with the Spirit. This must certainly be a very good method; because decrepitated Sea-salt powerfully attracts moisture, and consequently is very apt to imbibe and retain that which is in the Ardent Spirit: and Spirit of Wine doth not dissolve Sea-salt; so that there is no reason to fear its being in the least contaminated therewith.

All fermented liquors do not yield near an equal quantity of Ardent Spirit; because they do not all, before fermentation, equally contain the principles necessary to produce an Ardent Spirit, in the most advantageous proportion or disposition.

There are several ways of proving whether or no Spirit of Wine be as highly rectified as it possibly can be, that is, whether or no it contain any more phlegm than is precisely necessary to constitute it Spirit of Wine; and many Chymists have judged that worthy of the title which burns away entirely, without leaving behind it the least token of humidity; or that which, being burnt on gun-powder, fires it at last.

But Mr. Boerhaave justly observes that neither of these is a sufficient proof; because, though there should be a small quantity of unnecessary phlegm in Spirit of Wine, yet it may very well be evaporated and dissipated by the deflagration in either way. He therefore proposes another proof, which is much more to be depended on; that is, by mixing and shaking with the Spirit of Wine a small quantity of a very dry pulverized Alkali. If this Salt, when thus agitated, and even warmed, with Spirit of Wine, continue as dry as it was at first, it is a sign that the Spirit is perfectly dephlegmated.

Mr. Boerhaave tried in this manner some Spirit of Wine that had fired gun-powder, and found it to contain so much phlegm that it moistened his Salt very perceptibly : nay, one single drop of water being mixed with a considerable quantity of Spirit of Wine, which before left the Alkali perfectly dry, discovered itself in this way by the moisture it communicated to the very same Salt.

Spirit of Wine may also be contaminated with some heterogeneous substances ; such as acid, alkaline, or oily matters. These are to be discovered by very easy experiments proper to each : for an acid or alkalious Spirit of Wine being mixed with Syrup of violets will give it a red or a green colour, according to the nature of the saline matter contained in it ; and, if it be combined with an Oil, that will shew itself by the white milky colour which a drop of it will give to water.

Besides the Ardent Spirit, Wine contains an Acid united with a portion of earth and of Oil, which give the Acid a concrete form. This substance generally separates spontaneously from the Wine, and adheres, in the form of a strong crust, to the sides of the cask. It is called Tartar, and is, properly speaking, the Essential Salt of Wine. We shall exhibit the analysis of Tartar, and treat of it more at length, in a Chapter apart.

Wine-lees consist of the grossest parts of the fermented liquor ; which being incapable of remaining dissolved, sink to the bottom, and form a sediment, which contains also some Tartar and a little Ardent Spirit.

The residue left in the cucurbite, after the Spirit is drawn off, is a sort of Extract of Wine. This liquor hath an exceeding rough, or rather acid taste. When distilled it yields an acid phlegm, which comes more and more acid as the distillation advances, and a fetid empyreumatic Oil. From the

caput

caput mortuum, when burnt, a considerable quantity of a Fixed Alkali may be extracted.

From all this it follows that Wine consists of an Ardent Spirit, and a Tartarous Acid, diffused through a great quantity of water, together with some oily and earthy parts.

Malt-liquor contains much less Tartar than Wine; but, instead thereof, it is impregnated with a mucilaginous matter, which becomes very perceptible when any body is smeared with it and dried; for then it makes a kind of varnish. This mucilaginous matter, which is not sufficiently attenuated, especially when the malt-liquor is new, makes it very apt to swell up and rise over the helm with rapidity, in the distillation of an Ardent Spirit from it: for which reason it is necessary to proceed more cautiously, and more slowly, in distilling a Spirit from this liquor than from Wine.

P R O C E S S I I I .

To dephlegmate Spirit of Wine by the Means of Fixed Alkalis. Spirit of Wine analyzed.

INTO a glass cucurbite pour the Spirit of Wine you intend to dephlegmate, and add to it about a third part of its weight of Fixed Alkali, newly calcined, perfectly dry, heated, and pulverized. Shake the vessel, that the two matters may be mixed and blended together. The Salt will gradually grow moist, and, if the Spirit of Wine be very aqueous, melt into a liquor, that will always lie at the bottom of the vessel, without uniting with the Spirit of Wine, which will swim at top,

When you perceive that the Alkali attracts no new moisture, and that no more of it melts, decant your Spirit of Wine from the liquor beneath it, and

add to your Spirit fresh Salt thoroughly dried as before. This Salt also will imbibe a little moisture; but it will not grow liquid, because the Alkali, with which it was mixed before, hath left too little phlegm to melt this. Decant it from this Salt as at first, and continue to mix and shake it in the same manner with fresh Salt, till you observe that the Salt remains as dry after as it was before mixing it with the Spirit of Wine. Then distill your Spirit in a small alembic with a gentle heat, and you will have it as much dephlegmated as it can be.

O B S E R V A T I O N S.

NEXT to the Mineral Acids, Fixed Alkalis perfectly calcined are the substances which have the greatest affinity with water, and therefore it is no wonder they are so very fit to dephlegmate Spirit of Wine, and to free it from all its redundant humidity. Indeed Spirit of Wine cannot be perfectly dephlegmated without their assistance: for when distillation alone is made use of for that purpose, it is impossible to prevent some phlegm from rising with the Spirit of Wine, whatever precautions we take to avoid it. Hence it comes to pass that Spirit of Wine, though ever so highly rectified by distillation, always imparts a little moisture to an Alkali, when mixed with it in order to prove its goodness.

But, while the Alkali attracts the super-abundant phlegm of the Spirit of Wine, it produces in that liquor, and undergoes itself, remarkable changes.

Spirit of Wine, when so highly dephlegmated by an Alkali that, being kept in digestion therewith, it leaves the Salt perfectly dry, hath a red colour, an odour somewhat different from that which is peculiar to it when perfectly pure, a taste in which that of the Fixed Alkali may be distinguished; and it makes a slight effervescence with Acids: which manifestly
proves

proves that it is united with a portion of the Alkali employed to rectify it.

Mr. Boerhaave thinks, with great probability, that this portion of the Alkali unites with the Spirit of Wine, much in the same manner as with Oils, viz. that it forms with the Spirit a kind of liquid Soap. He observes that this alkalized Spirit cleans the fingers; and that things wetted with it do not dry so speedily as those wetted with pure Spirit of Wine. This alkalized Spirit is also called *Tincture of Salt of Tartar*.

In making this Alkaline Tincture, great care is to be taken that the Spirit of Wine you use be as highly rectified as possible: for, as long as it communicates any phlegm to the Alkali, it doth not acquire from the Salt mixed with it either the red colour, or the other properties which shew it to have dissolved part thereof. It is also a rule to throw the Alkali exceeding hot into the Spirit of Wine, which being heated before hand boils on the addition of the hot Salt. In order to render the Tincture still stronger, they are left to digest together for some time; after which, if part of the Spirit of Wine be drawn off by distillation, the remainder will have a redder colour and a more acrid taste.

The Spirit drawn off by distillation is clear, colourless, and doth not give the same tokens of an Alkaline quality as the Tincture; and for that reason, as the design of the present process is only to dephlegmate and rectify Spirit of Wine by means of a Fixed Alkali, we have directed it to be distilled as soon as all its phlegm is absorbed by the Salt.

However, Spirit of Wine rectified in this manner must not be considered as absolutely pure; for a small degree of an Alkaline quality is still perceptible in it: but that doth not hinder its being employed with success in several Chymical operations, where
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the property chiefly required in Spirit of Wine is that it be perfectly dephlegmated.

In order to free Spirit of Wine from the small portion of Alkali remaining in it after distillation, Mr. Boerhaave proposes to mix with it a few drops of the Vitriolic Acid, before the last distillation. But there is great reason to apprehend an opposite inconvenience from this practice: that is, instead of an Alkaline character, we may give the Spirit an Acid taint. Indeed this cannot be avoided, but by mixing with the Spirit of Wine exactly as much Acid as suffices to saturate the Alkali contained in it, and no more; which is a point very difficult to hit.

Van Helmont tells us that having distilled Spirit of Wine from Salt of Tartar perfectly calcined, half of it came over pure water; and Mr. Boerhaave, to whom this appeared very surprising, resolved to repeat Van Helmont's experiment, in order to satisfy himself of the truth, and see with his own eyes what would be the result. With this view he made a tincture of Salt of Tartar in the manner above described, as strong and as fully impregnated as he possibly could. He set it in digestion with the Alkali for several months, and afterwards let it stand four years without touching it. He then poured the whole into a cucurbite, and drew off the Spirit of Wine from the Salt by distillation. The Spirit of Wine, which was before very red, became clear on being distilled, having left its colour in the Salt which remained in the bottom of the cucurbite. This Spirit he returned upon the Salt, and distilled as before. He observed, that, in this second distillation, the Spirit of Wine rose with a little more difficulty, and that the remaining Salt was of a more saturated colour, and become of a dark red. In this manner he cohobated and distilled his Spirit twenty times, with the same Salt. He then found
that

that the Spirit of Wine had acquired a caustic, fiery taste, and that the saline mass in the bottom of the cucurbite was grown black. This saline residue he distilled with a stronger fire, and obtained from it a liquor, which was water, and not Spirit of Wine.

Though Mr. Boerhaave seems, by this tedious labour, to have made Van Helmont's experiment succeed, at least in part, yet that famous and accurate Philosopher did not flatter himself with the notion of having solved the problem. He first observes that he was far from getting the quantity of water which Van Helmont says he obtained, viz. half the weight of the Spirit of Wine. Secondly, he could scarce think that the quantity he did obtain actually came from the Spirit of Wine. The thing appeared to him so singular, and so hard to be accounted for, that he inclined to believe the water was quite extraneous both to his Spirit of Wine and to his Salt, and that it came from the air, which could not but be admitted in the frequent cohobations of the Spirit of Wine with the Alkali.

When Mr. Boerhaave undertook this long laborious course of operations, he had it also in his view to try whether he could not, by the same means, solve another problem famed among the Chymists, namely the Volatilization of the Salt of Tartar. He acquaints us that in this also he failed; which may easily be believed: but, in my opinion, he was more successful, with regard to the first point, than he himself imagined; for I think the water he obtained came immediately from the Spirit of Wine. We shall easily be convinced of this, if we carefully consider all the circumstances attending his experiments.

It hath been shewn that Spirit of Wine consists of an Oil, of an Acid, and of water, with which the Oil is intimately mixed by means of the Acid; that
Spirit

Spirit of Wine, which is not perfectly dephlegmated, may be deprived of a pretty considerable quantity of water, which is superfluous and unnecessary to its composition ; and that it suffers no change thereby, except that it becomes lighter, stronger, more inflammable, in short, more Spirit of Wine: but that, when it is once freed of this super-abundant phlegm, it would be in vain to attempt separating a greater quantity of water from it. All the water then left in it is essential to its composition, and necessary to give it its properties ; for without that, it would not be Spirit of Wine, but only an Oil loaded with an Acid.

This being laid down, the water which cannot be separated from Spirit of Wine while it continues Spirit of Wine, must become sensible when it is decomposed. And this actually comes to pass : for if you rob Spirit of Wine of one of its principles, its Oil, for instance, and for that purpose burn it under a glass bell, as you do Sulphur, you will by this means collect a great quantity of water, even though you make use of the most highly rectified Spirit of Wine ; which proves that this water was one of the essential parts that constituted the Spirit.

If, instead of depriving this mixt of its oily principle, you separate from it one of its other principles, such as its Acid, it is plain that it will in like manner be decomposed, and that then the Oil and the water, which were combined together only by means of that Acid, will separate from one another, and appear each in its natural form. Now this is exactly the case in Van Helmont's experiment, as repeated by Boerhaave. The Fixed Alkali, on which the Spirit of Wine is cohobated, hath a greater affinity with the Acid of this mixt than with its phlegm or its Oil. It therefore unites with part of that Acid ; by which means a proportional quantity of its Oil and water must needs separate from each

each other, and of course a portion of the Spirit of Wine will be decomposed. Accordingly Boerhaave observed, that, in dephlegmating Spirit of Wine by a Fixed Alkali, a portion of Oil is always separated from it, and that the Alkali employed in this operation is impregnated with an Acid, so that, when it hath been several times used for this purpose, it is almost changed into a Neutral Salt, and hath acquired the properties of the Foliated Salt of Tartar. That on which Spirit of Wine hath been cohobated a great number of times must consequently be impregnated with a great quantity of Acid; and, as the Acid carries with it a great deal of water, it is not surprising that when the Alkali, thus impregnated with Acid and phlegm, is exposed to a strong fire; the phlegm should be separated from it; seeing the union between them is but weak.

Thus it appears that the water obtained by Mr. Boerhaave, in his experiment, came immediately from the Spirit of Wine, agreeably to Van Helmont's notion; whose most intelligent followers have clearly explained his sentiments on this subject, telling us, as their author's positive assertion, that,

“ in his experiment, the purest Spirit of Wine de-
 “ posites one of its principles in the Salt of Tartar;
 “ that another of them is turned into water; and so
 “ separated from that Spirit, and from the principle
 “ attracted by the Salt of Tartar; that consequently
 “ Spirit of Wine certainly consists of these two
 “ principles, which may be separated from each
 “ other; and that the principle which unites with
 “ the Alkali of the Tartar changes that Salt into a
 “ medicament, or Balsam, of admirable virtue in
 “ curing wounds, known by the title of the *Samech*
 “ of *Paracelsus*.”

It may here be asked why Boerhaave obtained but a small quantity of water in his experiment, seeing Van Helmont pretends that it ought to be equal to
 half

half the weight of the Spirit of Wine. The most natural answer to this question is, that, as Van Helmont did not publish all the circumstances of his experiment, there is reason to think Boerhaave did not go about it in the same manner as Van Helmont did.

In my opinion he would have succeeded perfectly, and have obtained from his Spirit of Wine the whole quantity of water he desired, if, instead of cohobating it always on the same Alkali, he had taken fresh Alkali every time; had drawn a tincture from it; had distilled his Spirit of Wine from this Salt; and, after collecting all the parcels of Alkali remaining after those distillations, he had exposed them to a strong fire, in order to separate all the moisture contained in them. Perhaps also such a great number of cohobations and distillations would not have been necessary to decompose the Spirit of Wine totally by this method; especially if he had employed a greater quantity of Alkali in each operation. For it is evident that a Fixed Alkali, by being impregnated with a certain quantity of the Acid and water of the Spirit of Wine, loses thereby a great deal of its strength and activity, and at last becomes incapable of absorbing any more; so that, when it is entirely saturated, it is no more able to act upon Spirit of Wine, so as to decompose it, than so much Vitriolated Tartar, or common Sand. Hence you see that there are still many beautiful experiments to be made on this subject, and that we may hope by a regular course of them to obtain a perfect solution of Van Helmont's problem.

In the following processes we shall treat of another method of decomposing Spirit of Wine, which consists in depriving it of its essential water, or aqueous principle, by the means of highly concentrated Acids.

C H A P. II.

SPIRIT OF WINE COMBINED WITH DIFFERENT
SUBSTANCES.

P R O C E S S I.

*To combine Spirit of Wine with the Vitriolic Acid.
This combination decomposed. Rabel's Water.
Æther. Sweet Oil of Vitriol. Hoffman's Anodyne
Mineral Liquor.*

INTO an English glass retort put two pounds of Spirit of Wine perfectly dephlegmated, and pour on it at once two pounds of highly concentrated Oil of Vitriol: shake the retort gently several times, in order to mix the two liquors. This will produce an ebullition, and considerable heat; vapours will ascend, with a pretty loud hissing noise, which will diffuse a very aromatic smell, and the mixture will be of a deeper or lighter red colour, according as the Spirit of Wine was more or less oily. Set the retort on a sand-bath, made nearly as hot as the liquor; lute on a tubulated ballon, and distill the mixture with a fire strong enough to keep the liquor always boiling: a very aromatic Spirit of Wine will first come over into the ballon, after which the Æther will rise. When about five or six ounces of it are come off, you will see in the upper concavity of the retort a vast number of little points in a veined form, which will appear fixed, and which are nevertheless, so many little drops of Æther, rolling over one another, and trickling down into the

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receiver. These little points continue to appear and succeed each other to the end of the operation. Keep up the same degree of fire, till upon opening the little hole in the ballon you perceive that the vapours, which instantly fill the receiver, have the suffocating smell of Volatile Spirit of Sulphur*.

Then unlute the ballon, pour the liquor it contains into a crystal bottle, and stop it close: there will be about eighteen ounces of it. Lute on your receiver again, and continue the distillation with a greater degree of fire. There will come over an aqueous, acid liquor, smelling strong of a sulphureous spirit, which is not inflammable. It will be accompanied with undulating vapours; which being condensed will form an Oil, most commonly yellow, one part of which will float on the surface of the liquor, and another will sink to the bottom.

Towards the end of the distillation of this acid liquor, and of the yellow Oil of which it is the vehicle, that part of the mixture, which is left in the retort and grown black, will begin to rise in froth. Then suppress your fire at once; stop the distillation, and change your receiver once more. When the vessels are grown pretty cool, finish your distillation with a lamp-heat, kept up for twelve or fifteen days, which in all that time will raise but a very little sulphureous spirit. Then break your

* These white vapours do not appear when the vessels are perfectly close. Mr. *Hellot*, to whom we owe the remark, having performed this operation in a crystal retort procured from *London*, the neck of which had been rubbed with emery in the mouth of its receiver, so that these two vessels fitted each other exactly, saw the ætherial liquor distill pretty fast, but without white vapours. He then loosened the receiver, by turning it a little upon the neck of the retort, so that the external air might get in; whereupon the white vapours appeared immediately. When the receiver was close fitted on again, the vapours disappeared. He repeated the same thing five times from half hour to half hour, and these vapours as often appeared and disappeared.

retort, in which you will find a black, solid mass, like a Bitumen. It will have an acid taste, arising from a remainder of the Acid imperfectly combined with Oil.

This artificial Bitumen may be freed from its redundant Acid, by washing it in several waters. Then put it into a glass retort, and distill it with a strong reverberated fire. You will obtain a reddish Oil that will swim on water, much like the Oil obtained by distilling the natural Bitumens. This Oil also will be accompanied with an aqueous acid liquor. In the retort will be left a charred matter, which, being put into an ignited crucible in the fire, burns for some time, and, when well calcined, leaves a white earth.

The liquors that rise first in this distillation, and which we directed to be kept by themselves, are a mixture consisting 1. of a highly dephlegmated Spirit of Wine, of a most fragrant smell; 2. of Æther, which the Spirit of Wine wherewith it is united renders miscible with water; 3. of a portion of Oil, which commonly rises with the Æther, towards the end of the operation; 4. and sometimes of a little Sulphureous Acid, if the receiver be not changed soon enough.

In order to separate the Æther from these other substances, put the whole into an English retort, with a little Oil of Tartar *per deliquium* to absorb the Sulphureous Acid, and distill very slowly in a sand-bath heated by a lamp, till near half the liquor be come over. Then cease distilling; put the liquor in the receiver into a phial with some water, and shake it; you will see it rise with rapidity to the upper part of the phial, and float on the surface of the water; this is the Æther.

OBSERVATIONS.

THIS operation is only a decomposition of Spirit of Wine by means of Oil of Vitriol. In the preceding

ceding process we saw that this Spirit, which consists of three essential principles, viz. an Oil, an Acid, and Water, cannot be deprived of one of them without being at the same time decomposed; the two others that remain having, by such separation, lost the bond of intimate union and connection that was between them. We saw also that Spirit of Wine, when mixed and digested with a very caustic Fixed Alkali, and several times distilled from it, deposits its Acid in that Salt: and hence it comes that the Oil and the Water, being deprived of the principle which was the bond of their union, separate from each other, and appear in their natural forms.

In the present experiment the Vitriolic Acid decomposes the Spirit of Wine in a different manner. We know that this Acid acts powerfully on Oils; and that, when it is highly concentrated, as the operation requires it should be, it seizes and attracts with surprising force the moisture of all bodies that touch it. So that, when it is mixed with Spirit of Wine, it acts at the same time both on the aqueous and on the oily principle of that mixt. The rapidity and activity wherewith it rushes into union with these substances, produce the heat, the ebullition, and the hissing noise, which we observe during the first moments after their mixture.

The red colour, which the two liquors confounded together acquire after some time, is owing to the combination of the acid with the oily part: for it is known that Oils as colourless as Spirit of Wine, such as the Essential Oil of Turpentine, become of a brownish red when dissolved by a concentrated Acid: and Kunckel observed, that, the more Oil there is in Spirit of Wine mixed with Oil of Vitriol, the deeper is the red colour it acquires on being so mixed. He even gives this experiment as the certain means of discovering whether Spirit of Wine be more or less oily; and he adds, that Spirit of
Wine,

Wine, which hath lost part of its Oil by being rectified with Lime, acquires less redness than any other by being mixed with Oil of Vitriol.

When the mixture hath acquired this colour, and before it undergoes distillation, it appears like a homogeneous liquor. There is as yet no decomposition; or at least none that is perceptible; and the Vitriolic Acid is united at the same time with the Oil, the Acid, and the Water of the Spirit of Wine; that is, with the whole Spirit of Wine in substance. This mixture, when made with three parts of Spirit of Wine to one of Oil of Vitriol, is an astringent remedy much used in hemorrhages, and known by the name of *Rabel's Water*.

The actual decomposition of the Spirit of Wine is effected by the distillation. The first liquor, or the first portion of the liquor that rises before the rest, hath the smell and all the properties of Spirit of Wine. It is indeed part of the Spirit of Wine employed as an ingredient in the mixture; but, being abstracted from a highly concentrated Oil of Vitriol, which, of all known substances, attracts moisture with the greatest power, it is perfectly freed of all its unnecessary phlegm, and retains no more than what is a constituent part thereof, as one of its principles, without which it would not be Spirit of Wine.

The liquor that succeeds this first Spirit of Wine is of a different nature. It may be considered as an Æther: for, though it be not a pure Æther, it contains the whole of it: from this liquor only can it be obtained; it is no other than an Æther mixed with some of the Spirit of Wine that comes over first, and a little of the Acid liquor which comes afterward. Now the production of Æther is the effect of a beginning decomposition of the Spirit of Wine: it is Spirit of Wine degenerated, half-decomposed; Spirit of Wine too highly dephlegmated; that is, Spirit of Wine which hath lost a part

of its essential phlegm, of that phlegm which as a necessary principle made it Spirit of Wine: it is a liquor still composed of oily parts mixed with aqueous parts, and on that account must retain a resemblance of Spirit of Wine; but such that its oily parts, not being dissolved and diffused among a sufficient number of aqueous particles, are brought nearer to each other than they should be to constitute perfect Spirit of Wine; on which account it is not now miscible with water, but is as much nearer to the nature of Oil, as it is removed from the nature of Spirit of Wine: it is a liquor, in short, which, being neither Spirit of Wine nor pure Oil, yet possesses some properties in common with both, and is consequently to be ranked in the middle between them.

This explanation of the nature of Æther, which I imagine was never before given by any other, is the same that we proposed in our Elements of the Theory of Chymistry, which may be consulted on this occasion.

An objection against this opinion may, perhaps, be drawn from an experiment well known in Chymistry. It may be said, that, if Æther were nothing but depraved Spirit of Wine, which ceases to be miscible with water, because the loss it hath sustained of a portion of the water necessary to its constitution hath disordered the proportion which ought to subsist between its aqueous and oily parts, from which proportion it derives that property, it would be very easy to change Spirit of Wine into Æther by a method quite contrary to the usual one; viz. by mixing Spirit of Wine with a sufficient quantity of superfluous Oil: for it seems to be a matter of indifference whether the proportion, between the aqueous and the oily parts of Spirit of Wine, be changed by lessening the quantity of the former, as in the common operation for Æther, or by increasing the quantity

quantity of the latter, as is here proposed; and we can, by the last method, put these two principles together in what proportion we please. Now it is certain that, whatever quantity of Oil be dissolved in Spirit of Wine, it will still remain miscible with water; and that, if Spirit of Wine thus replete with Oil be mixed with water, it will unite therewith as usual, and quit the Oil which it had dissolved.

This objection, though seemingly a very specious one, will be removed with the utmost ease, if we reflect but ever so little on some of the principles already laid down. We said, and we gave some instances of it, that certain substances may be united together in sundry different manners; so that from these combinations, though made in the same proportions, there shall result compounds of very dissimilar properties. The combination we are now considering is another evidence of this truth. It is allowed that the proportion between the oily and the aqueous parts may be exactly the same in *Æther* and in Spirit of Wine replete with Oil; but it must also be owned that the manner in which the Oil is combined in these two cases is very different.

That Oil, which at first is a constituting part of the Spirit of Wine, and afterwards becomes a part of the *Æther*, is united with the other principles of those mixts, that is, with their Acid and their Water, by the means of fermentation, whereby it is much more attenuated, and much more closely combined, than that with which Spirit of Wine is impregnated by dissolution only. And accordingly this adventitious Oil is so slightly connected with Spirit of Wine, that it is easily separable from it by barely distilling it, or even mixing it with water: whereas that which makes a part of Spirit of Wine, as one of its constituent principles, is united therewith in such a manner as not to be separable from it by either of these methods, nor indeed without employing

the most vigorous and powerful agents for that purpose. So that the chief differences between *Æther* and Oily Spirit of Wine must be ascribed to the different manner in which the Oil is combined in these two mixts: and, if a sufficient quantity of superfluous Oil could be united with Spirit of Wine, in such a manner that, without being soapy, it should not be separable therefrom by the affusion of water, I make no doubt but such a Spirit of Wine would be perfectly like *Æther*, so far as not to be miscible with water.

But let us return to our distillation, and trace the decomposition of Spirit of Wine by the Vitriolic Acid. We have shewn that the Acid begins with attracting part of the Water which constitutes the Spirit of Wine, by which means it changes the nature of this compound, destroys its miscibility with water, and brings it as much nearer to the nature of an Oil, as it thereby removes it from the nature of Spirit of Wine.

According to the theory laid down it is evident, that, if the Acid continue to act in the same manner on Spirit of Wine thus depraved and become *Æther*; that is, if it continue to draw from it the small remaining quantity of the aqueous principle, to which it owes the properties it still retains in common with Spirit of Wine, this must produce a total decomposition thereof; so that the oily parts, being no longer dissolved and divided by the aqueous parts, will be collected together, unite, and appear under their natural form, with all their properties. Now this is exactly the case. The Vitriolic Acid rises in the distillation after the *Æther*; but considerably changed, because it is loaded with the scattered remains of the decomposed Spirit of Wine. It is in a manner suffocated by the Water it hath attracted from the Spirit; which is the reason why it appears in the form of a very aqueous acid liquor.

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It carries up along with it the Oil which it hath separated from that water: this is the Oil we took notice of in the process; and it is consequently that very Oily principle which actually constituted the Spirit of Wine. Lastly, by acting on this Oil also, it takes up a portion of Phlogiston, which renders it sulphureous.

What remains in the retort is also a portion of the Oil, that was contained in the Spirit of Wine, now combined with some of the Acid; which is the reason why it is black and thick. It is a compound much resembling a Bitumen, and when analyzed yields the same principles we obtain from native Bitumens, or from an Essential Oil thickened and half-burnt by its combination with concentrated Oil of Vitriol.

As to the Acid of the Spirit of Wine, some of it remains combined with the Æther: but there is great reason to think, that, when the Vitriolic Acid robs the Spirit of Wine of its aqueous part, it takes up at the same time most of its Acid; which being itself very aqueous, may be considered as pure water with respect to the concentrated Oil of Vitriol, by which it is attracted, and with which it is confounded.

The properties which characterize Æther agree perfectly well with what we have said of its nature, and of the manner in which it is produced. It is one of the lightest liquors we know; it evaporates so suddenly, that, if a little of it be dropt on the palm of your hand, you will scarce perceive the part it touches to be wet by it; it is more volatile than Spirit of Wine; which is not at all surprising, seeing it differs therefrom only by containing less water, which is the heaviest principle in Spirit of Wine.

Æther is more inflammable than Spirit of Wine; for, if any flame be brought but near it, it imme-

diately catches fire. The reason of this is, that the oily parts of which it consists are not only as much attenuated, and as subtile, as those of Spirit of Wine, but also in a greater proportion with regard to its aqueous parts. To the same cause must be attributed the facility with which it dissolves any oily matters whatever.

Æther burns without smoak, as Spirit of Wine does, and without leaving any coal or earthy matter behind; because the inflammable or oily parts contained in it are, in this respect, disposed like those of Spirit of Wine.

The properties of not being miscible with water, and of taking up Gold dissolved in *Aqua Regis*, it possesses in common with Essential Oils; but the latter property it possesses in a much more sensible degree than any Oil: for Essential Oils sustain the Gold they thus take up but a little while; whereas the Æther never lets it fall. It seems the ancient Chymists were unacquainted with the Æther; or at least, if they did know it, they made a mystery of it, according to custom, and spoke of it only in enigmatical terms. Amongst the moderns Frobenius, a German Chymist, seems to have been the first who brought it to perfection. Godfrey Hankwitz, also a German, but settled in England, made mention of it much about the same time in the Philosophical Transactions. According to the latter, Mr. Boyle and Sir Isaac Newton both knew the preparation of Æther, for which they had each a different process. But none of these Chymists ever published an exact and circumstantial account of a method by which this liquor might be prepared; so that Mess. Duhamel, Grosse, and Hellot, who have since made several experiments for that purpose, and have discovered, and communicated to the public, easy and certain methods of procuring Æther, had no assistance in their labours but from their

their own skill and sagacity; which gives them a just title to the honour of the invention. Mr. Beaumé also, a very ingenious artist in Paris, who hath bestowed a great deal of pains on this subject, lately communicated to the Academy a Memoir, which, among several very important observations, contains the commodious and expeditious process above inserted. As there are many experiments in Mr. Hellot's Mémoire, agreeing perfectly well with what hath been said concerning the decomposition of Spirit of Wine by the Vitriolic Acid, we think it will be proper to take notice of them here, and to examine them briefly at least.

The quantity, the colour, and the weight of the Oil, which rises in the distillation at the same time with the aqueous acid liquor, are various, according to the different proportions of Spirit of Wine and Oil of Vitriol that are mixed together. Mr. Hellot observed that by increasing the quantity of the Vitriolic Acid he obtained more of this Oil, and less of the Ardent Spirit containing the Æther. The reason is this: the more Oil of Vitriol you put in the mixture, the more Spirit of Wine must be totally decomposed, and consequently the more of this Oil will be obtained; which, as we have shewn, is one of the principles resulting from the decomposition of Spirit of Wine.

“ This Oil is also lighter or heavier, in proportion to the quantity of Oil of Vitriol poured on the Spirit of Wine. That which arises from mixing six, five, four, or even three parts of Spirit of Wine with one part of concentrated Oil of Vitriol, always floats on the water, and continues white. That which ascends from two parts of Spirit of Wine is yellow, and most commonly sinks; and, lastly, that which is produced from
 “ equal

“ equal parts of these two liquors is greenish, and
 “ constantly falls to the bottom.”

Mr. Hellot remarks, on this occasion, that part of the Acid, by the intervention of which this Oil is separated, unites therewith; and, to the greater or smaller quantity of the Acid thus combined with the Oil, he imputes its being more or less ponderous: which is the more probable, as the heaviest Oil is always obtained from a mixture in which the Acid bears the greatest proportion; and *vice versa*. Perhaps the different specific gravity of Essential Oils is wholly owing to the greater or smaller quantity of Acid they contain.

Mr. Hoffman hath made several Observations on this Oil, which evidently prove that it contains much Acid. He says, that, if it be kept for some time in a bottle, it grows red, and loses its transparency; that its agreeable aromatic taste becomes acid and corrosive; and that if you hold it over the fire in a silver spoon, it corrodes it, and leaves a black spot on it; and that it also corrodes Mercury, when heated therewith in a matrafs. To this Mr. Pott adds that it makes a very perceptible effervescence with Fixed Alkalis; and that being rectified by those Salts it loses all the acid properties observed by Mr. Hoffman.

Mr. Hellot obtained a still more considerable quantity of this Oil, by adding three or four ounces of a Fat Oil to the mixture of Spirit of Wine with the Vitriolic Acid. Now, as the Oil we are speaking of hath the properties of Essential Oils, and is soluble in Spirit of Wine, Mr. Hellot observes that Oil of Vitriol by uniting with Fat Oils converts them into Essential Oils: which agrees very well with our opinion concerning the cause of the solubility of Oils in Spirit of Wine; which, in the Memoir already referred to on other occasions, we
 at-

attribute to an Acid superficially and slightly united with Oils.

The Oil which thus rises in distilling Spirit of Wine mixed with the Vitriolic Acid, is known by the name of the *Sweet Spirit of Vitriol*. This name is very improper, because it may suggest a notion that this Oil derives its origin from the Vitriolic Acid, as some Chymists have erroneously thought; whereas it comes entirely from the Spirit of Wine, as we have shewn. If any reason can be assigned for keeping up the name, it must be because of the considerable quantity of the Vitriolic Acid that remains in the combination, and is dulcified by its union with the Spirit of Wine.

This Oil is an ingredient in Hoffman's famous *Anodyne Mineral Liquor*. That liquor is thought to be nothing but this very Oil dissolved, and combined with the two liquors that rise first in the distillation, and immediately before the Sulphureous Acid Phlegm. It dissolves very easily and quickly in those spirituous menstrua: so that, if you intend to have it by itself, and to prevent its re-combining with the liquors that come off before, (which should be prevented, because it hinders the separation of the Æther,) you must take great care to change the receiver as soon as the acid phlegm with which it rises, begins to appear.

We have seen that, by the methods which Mr. Hellot hath pointed out, this Sweet Oil of Vitriol may be increased, both in weight and quantity. In that ingenious Chymist's Memoir we also find some methods of preventing it from rising in the distillation. They consist wholly in the addition of some Absorbent bodies, which, he tells us, divert the action of the Vitriolic Acid, at least in some measure, from the inflammable part of the Spirit of Wine. One of these methods is as follows.

“ Put

“ Put into Spirit of Wine as much soft Soap as
 “ it can dissolve: filter it, and pour on it some of
 “ the heaviest and most concentrated Oil of Vitriol:
 “ shake the mixture. The Soap will be instantly
 “ decomposed, and its Oil will float on the sur-
 “ face; because the Vitriolic Acid robs it of the
 “ Alkali, which renders it miscible with Spirit of
 “ Wine. Distill it, and you will obtain but a very
 “ little of Rabel’s Water; which moreover will
 “ have the most disagreeable smell of a rancid Oil.
 “ There will afterwards ascend a great quantity of
 “ Spirit of Wine having the same smell; then an
 “ aqueous, acid, and sulphureous liquor; but not
 “ a drop of yellow Oil. Mean time there forms
 “ a bituminous fungus, of some consistence, rising
 “ above the Oil of the Soap which floats on the rest
 “ of the liquid.”

Most of the Vitriolic Acid having been absorbed
 by the Alkali of the Soap, in this experiment, as
 Mr. Hellot observes, it is not surprising that it
 should not act upon the Spirit of Wine with so much
 efficacy as to decompose it, and separate its Oil.
 For the same reason but a little of Rabel’s Water
 comes over, and almost all the Spirit of Wine rises
 without undergoing any sensible alteration. The
 disagreeable smell of those liquors comes from the
 Oil of the Soap, which being naturally heavy, re-
 mains behind in the retort, where it grows rancid,
 and is partly burnt.

The last experiment in Mr. Hellot’s Memoir, of
 which we shall take notice, is a peculiar process for
 preparing *Æther*; by means whereof, with the help
 of an earthy medium, it is easy to distill the vinous
 acid Spirit containing the *Æther*, without any sen-
 sible change of smell from the beginning to the end
 of the operation; without its being succeeded by an
 acid sulphureous liquor, oil, black scum, resin, or
 bitumen; and without the necessity of taking any
 great

great care about the management of the fire, as the liquor may always be kept boiling in the retort, and distilled to dryness without any danger. This medium is common potter's earth. Mr. Helot puts six ounces thereof, well dried and pulverized, into a large retort, with one pound of Spirit of Wine and eight ounces of Oil of Vitriol. These he digests together three or four days. The mixture acquires no sensible colour. He sets the retort in a sand-bath, and continues the distillation to dryness with a moderate charcoal fire. Excepting a few drops that rise first, and which are pure Spirit of Wine, all the rest of the liquor that distills hath constantly the smell of *Æther*; which is even somewhat more penetrating than that of the vinous acid Spirit obtained without the intervention of this earthy medium.

We have shewn that the production of the æthereal liquor is owing to a semi-decomposition of the Spirit of Wine effected by the Vitriolic Acid during the distillation; that this Acid continuing to act produces a total decomposition, or perfect separation of the Oil and Phlegm of the Spirit of Wine from each other; and that the Vitriolic Acid, uniting with these two principles, forms the sulphureous phlegm, the fluid Oil, and the bituminous matter, all frequently mentioned above. Why then, in this experiment of Mr. Hellot's, do we obtain only a Spirit of Wine replete with *Æther*, while none of the other productions appear? The reason is a very natural one, and very clear: it is this; the potter's clay containing an earth of that kind which we called Absorbent, because it possesses the property of uniting with Acids, that earth joins with the Vitriolic Acid in the mixture, reduces it to a Neutral Salt, and thereby prevents its continuing to act upon the Spirit of Wine, as is necessary to the total decomposition thereof.

Mr.

Mr. Hellot says on this occasion, “ that part of
 “ the Vitriolic Acid turning its action on this so-
 “ luble earth or bole, which it finds in the potter’s
 “ clay, ceases to act on the inflammable principle
 “ of the Spirit of Wine; that, consequently, as
 “ there is not an immediate and continuous com-
 “ bination of these two substances, neither a resin
 “ nor a bitumen can result therefrom. This is so
 “ true that a great part of the Oil of Vitriol may be
 “ afterwards recovered from the potter’s clay, as
 “ colourless as when it was first used.”

Mr. Hellot makes use of the following method
 for procuring the Æther from the acid vinous Spirit
 obtained by this distillation. “ You must,” says he,
 “ put all this liquor into a glass body, made of one
 “ piece with its head; pour upon it, through the
 “ hole in the upper part of the head, twice or thrice
 “ as much well-water, the hardest to the taste, and
 “ the most impregnated with gypsum, that can be
 “ got. Very pure water, he observes, produces
 “ much less Æther.

“ If the vinous acid Spirit have such a sulphure-
 “ ous smell, as to occasion a suspicion that it con-
 “ tains a little too much of a Volatile Vitriolic Acid,
 “ you must add to the water two or three drams of
 “ Salt of potash to absorb that acid; and then distill
 “ with a lamp-heat.

“ While any true Æther remains in the mixture,
 “ you will see it ascend like a white pillar issuing
 “ from the midst of the liquor, and consisting of an
 “ infinite number of air bubbles inexpressibly small.
 “ Nothing seems to condense in the cavity of the
 “ head, which always remains clear, and without
 “ any visible humidity. The gutts which light on
 “ the sides of the receiver, instead of forming a
 “ net-work thereon, as Spirit of Wine doth when it
 “ is a little aqueous, spread to the breadth of two
 “ inches or more, when they consist of true Æther.
 “ As

“ As soon as you perceive this track begin to grow
 “ considerably narrower, the fire must be put out :
 “ for what rises afterwards will be mixed with water,
 “ and communicate that fault to the Æther already
 “ collected in the receiver.

“ Then pour this æthereal liquor into a long
 “ bottle, and add to it an equal quantity of well-
 “ water. Shake the bottle ; the liquor will become
 “ milky, and the true Æther will instantly separate,
 “ float upon the water, and mix no more with it.
 “ Separate it then by a siphon, and keep it in a glass
 “ bottle shut close with a glass stopple.”

P R O C E S S II.

*Spirit of Wine combined with Spirit of Nitre. Sweet
 Spirit of Nitre.*

INTO an English retort of crystal glass put
 some highly rectified Spirit of Wine; and, by
 means of a glass funnel with a long pipe, let fall
 into your Spirit of Wine a few drops of the Smok-
 ing Spirit of Nitre. There will arise in the retort
 an effervescence attended with heat, red vapours,
 and a hissing noise like that of a live coal quenched
 in water. Shake the vessel a little, that the liquors
 may mix thoroughly, and that the heat may be
 equally communicated to the whole. Then add more
 Spirit of Nitre, but in a very small quantity, and
 with the same precautions as before. Continue thus
 adding Spirit of Nitre, by little and little at a time,
 till you have put into the retort a quantity equal
 to a third part of your Spirit of Wine. Let this
 mixture stand quiet, in a cool place, for ten or
 twelve hours; then set it to digest in a very gentle
 warmth for eight or ten days, having first luted on a
 receiver to the retort.

During

During this time a small quantity of liquor will come over into the receiver; which must be poured back into the retort. Then distill with a somewhat stronger degree of heat, but still very gently, till nothing be left in the retort but a thick matter. In the receiver you will find a spirituous liquor, of a quick grateful smell, which will excite a very smart sensation on the tongue, but without any corrosive acrimony. This is *The Sweet Spirit of Nitre*:

OBSERVATIONS.

By this operation Spirit of Nitre is combined with Spirit of Wine; these two liquors being united with each other, much in the same manner as the Vitriolic Acid is with Spirit of Wine in Rabel's Water.

The proportion of the liquors which form this combination is not absolutely determined, and the several Authors who have written on the subject differ much about it. Some require equal parts of the ingredients: others again from two as far as ten parts of Spirit of Wine to one of Spirit of Nitre. This depends on the degree to which the Spirit of Nitre made use of is concentrated, and on the greater or less acidity which your dulcified Spirit of Nitre is intended to have.

The Dispensatory of the College of Paris orders one part of Spirit of Nitre distilled from dried clay, that is, of Spirit which doth not smoke, to be mixed with two parts of rectified Spirit of Wine, and the whole to stand in digestion for a month, without distilling the mixture at all. This is a very good method: because the long digestion supplies the place of distillation, and the Spirit of Nitre not being highly concentrated, doth not greatly alter the Spirit of Wine: besides that, many inconveniences; to be presently taken notice of, are by this means avoided.

But

But as our design is not to describe such Chymical preparations only as are commonly used in medicine, our plan requiring us to treat particularly of those which may give any light into the fundamental properties of bodies, the process here set down appeared the fittest for our purpose; because the action which Spirit of Nitre exerts upon Spirit of Wine is therein stronger and more perceptible.

One of the first particularities attending the mixture of those two liquors, is the great effervescence, accompanied with violent heat, abundance of fumes, and loud hissing, which arises as soon as the Spirit of Nitre and the Spirit of Wine come into contact with each other. There is great reason to think that these phenomena are produced only by the rapidity and vigour with which the Nitrous Acid rushes into union with the inflammable part of the Spirit of Wine. We observed, in treating of the *Æther*, that phenomena of the same kind appear at the instant when the Vitriolic Acid unites with Spirit of Wine: but on that occasion, how highly soever the Vitriolic Acid be concentrated, all these effects are in a less degree than those produced in the present experiment; because the Nitrous Acid, though weaker than the Vitriolic, generally acts much more vigorously and violently on the bodies with which it unites, than any other sort of Acid.

Concerning these mixtures of Acids with Spirit of Wine, Mr. Pott observes, that it is not a matter of indifference whether you pour the Spirit of Wine upon the Acid, or the Acid on the Spirit of Wine; but that every thing passes much more quietly, when the Acid is poured to the Spirit of Wine, than when the contrary is done: and he gives the true reason thereof; to wit, that when the Acid is poured on the Spirit of Wine it finds in that liquor

a great quantity of water, with which it immediately unites; that this weakens it, and hinders it from acting on the inflammable part with so much impetuosity as it otherwise would; and therefore he advises that such mixtures be always made in this manner. But it is evident that this advantage is gained only by mixing the Acid with the Spirit of Wine very gradually, and drop by drop, as directed in the process after Mr. Pott. For, if the two liquors were to be mixed together suddenly, and all at once, it is certain that the Acid would not meet with a single drop of phlegm more or less in that way than in the other.

Therefore the chief, and, in some measure, the only precaution necessary to be taken, in the making of such mixtures, to prevent the violent effervescence and other inconveniences that may attend it, such as explosion, and the bursting of the vessels, is to pour but a very small quantity of one liquor into the other at a time, and to add no more till the effervescence, and even the heat, produced by the first portion, be entirely ceased. With these precautions you may proceed either way, and be always sure that your vessels will not burst; because it is in your power to add such a small quantity of liquor at a time, as shall scarce produce a sensible effervescence. We own, however, that Mr. Pott's observation is a very just one. There is even an advantage in pouring the Acid to the Spirit of Wine, as he directs: which is, that the mixture is a little sooner made, and without any danger.

We have shewn that the Vitriolic Acid becomes aqueous and sulphureous by mixing Spirit of Wine with it: the Nitrous Acid is changed by this mixture in a manner no less remarkable. Mr. Pott observes that when Spirit of Nitre is dulcified, that is, when it is perfectly combined with Spirit of Wine, it loses the disagreeable odour peculiar to it, and acquires
another

another that is quick and fragrant; it doth not afterwards emit any red fumes; it rises with a less degree of heat than when pure; it acts with less vigour on Fixed Alkalis and Absorbent earths. Lastly, we shall here relate an experiment made by that Chymist, which seems to prove that the Nitrous Acid loses its most characteristic properties, and entirely changes its nature, by being combined with Spirit of Wine.

Mr. Pott examined the thick liquor left in the retort, when the dulcified Spirit of Nitre is distilled off. By analyzing it he obtained an acid liquor, of a yellow colour, and of a somewhat empyreumatic smell. This Acid was followed by some drops of a red empyreumatic Oil; and there remained, at the bottom of the distilling vessel, a black, shining, charred matter, like that which remains after the first rectification of a fetid Oil.

The Oil extracted from this residue is a portion of that which helped to constitute the Spirit of Wine; being separated therefrom by the Nitrous Acid, in the same manner as that treated of in the preceding process, and called *Sweet Oil of Vitriol*, is separated by the Vitriolic Acid. But as the Nitrous Acid, which is weaker than the Vitriolic, doth not so effectually decompose the Spirit of Wine, the Oil, obtained in the present experiment, is in smaller quantity, than that procured in the distillation of a mixture of the Vitriolic Acid with Spirit of Wine.

As to the Acid which Mr. Pott drew off in his experiment, there is great reason to think it a part of that which was an ingredient in the mixture; namely, of the Nitrous Acid. And yet Mr. Pott having saturated with a Fixed Alkali one part of the residuum, which he had a mind to examine before the Acid was separated from it by distillation, and expecting this matter to contain a regenerated Nitre,

he threw it on a live coal ; but was surpris'd to see it burn without the least sign of detonation ; and thence concluded that the Nitrous Acid had changed its nature. This experiment, he thinks, may furnish hints for the transmutation of Acids ; and he is of opinion that the Nitrous Acid loses its virtue of detonating, in the present case, only because its inflammable part, to which it owes its distinguishing properties, hath deserted it, and joined with that of the Spirit of Wine.

Indeed if the Acid obtained by Mr. Pott, which being reduced to a Neutral Salt doth not detonate, derives its origin from the Nitrous Acid that was combined with the Spirit of Wine, there is no doubt of its being depraved in a peculiar manner, and having entirely changed its nature. But may we not suppose it to have another origin ? May it not be the Acid of the Spirit of Wine itself, resulting from the decomposition of that mixt in the distillation ?

Mr. Navier, whom we mentioned in our Elements of the Theory, extracted a very singular oily liquor from the mixture of Spirit of Wine and Spirit of Nitre, without distillation, and even without the help of fire. He put equal parts of the two liquors, by measure, not by weight, into a bottle, which he stopp'd close with a good cork, fastened down with pack-thread. Nine days afterwards he found about a sixth part of the mixture separated from, and floating on, the rest of the liquor. This was a very fine æthereal Oil, very limpid, and almost as colourless as water,

In another experiment Mr. Navier substituted a solution of Iron in the Nitrous Acid for pure Spirit of Nitre ; and with this solution he mixed an equal weight of Spirit of Wine. From the mixture, after a fermentation which appeared in it, he obtained by the same method an æthereal Oil, like that of his
former

former experiment; except that the latter, which was at first as colourless as the other, acquired a redness in the space of about three weeks. He conjectures, with probability, that this colour proceeded from some particles of Iron which were united with it, and which gradually exhaled.

If a few drops of Oil of Tartar *per deliquium* be poured on this Oil, as soon as it is separated, there appears at first no sensible change therein: but after some time needle-like crystals shoot in it, which are a true regenerated Nitre; and if the bottle be then unstopped, the liquor emits a most pungent nitro-sulphureous odour; which leaves no doubt of this Oil's containing a Nitrous Acid. When it is thus freed of its Acid, by means of the Oil of Tartar, it is much more volatile than before.

Neither the Vitriolic nor the Marine Acid is capable of separating such an Oil from Spirit of Wine: but the Nitrous Acid always produces it, even when it is not concentrated, and doth not smoke.

It is very certain that this Oil derives its origin from the Spirit of Wine: but there are not yet experiments enough made upon it, to enable us to speak very accurately about the manner in which this liquor is formed, or of the cause of its separation from the Spirit of Wine.

P R O C E S S I I I.

*Spirit of Wine combined with the Acid of Sea-salt.
Dulcified Spirit of Salt.*

MIX together, little by little, in a glass retort, two parts of Spirit of Wine with one part of Spirit of Salt. Set this mixture to digest for a
S 3
month

month in a gentle heat, and distill it, till nothing remain in the retort but a thick matter.

OBSERVATIONS.

THE Acid of Sea-salt is much less disposed to unite with inflammable matters than the other two mineral Acids; and therefore, though it be ever so highly concentrated, when mixed with Spirit of Wine, it never produces an effervescence comparable to that which is produced by the Spirit of Nitre. Neither the proportion nor strength of the Spirit of Salt, requisite to prepare the Sweet Spirit of Salt, are unanimously agreed upon by Authors. Some direct equal parts of the two liquors; while others prescribe from two to four or five parts of Spirit of Wine to one part of Spirit of Salt. Some use only common Spirit of Salt; others require the Smoking Spirit, distilled by means of Spirit of Vitriol. Lastly, some order the mixture to be distilled, after some days digestion; and others content themselves with barely digesting it. The whole depends on the degree of strength which the Sweet Spirit of Salt is intended to have. This composition, as well as the Sweet Spirit of Nitre, is esteemed in medicine to be very aperitive and diuretic.

When the mixture of Spirit of Salt and Spirit of Wine is distilled, there comes over but one liquor, which appears homogeneous. This is the Sweet Spirit of Salt. The nature of the Marine Acid is not changed in this combination: the Acid is only weakened and rendered more mild; but in other respects it retains its characteristic properties.

Some Authors pretend that an Oil is obtained by distilling the mixture for the Sweet Spirit of Salt; but others expressly deny the fact. This variety may be occasioned by the quality of the Spirit of Wine employed. It would not be surprising if a Spirit of Wine, which contains much Oil that is
unne-

unnecessary to its nature, and, as it were, adventitious to it, should yield an Oil when distilled with Spirit of Salt.

The thick residue, found in the retort after distillation, contains the most ponderous part of the Acid, united with part of the Spirit of Wine. If the distillation be continued to dryness, there remains in the retort a black charred matter, much like that which is left by the combinations of Spirit of Wine with the other Acids.

A Sweet Spirit of Salt may also be prepared by digesting Spirit of Wine with, or distilling it from, metallic compositions replete with the Marine Acid adhering but slightly to them; such as Corrosive Sublimate, and Butter of Antimony. Part of this Acid, which is very highly concentrated, quits the metallic substance with which it is but superficially combined, in order to unite with the Spirit of Wine. If Butter of Antimony be used for this purpose, Mr. Pott, the author of these experiments, observes that a *Mercurius Vitæ* precipitates; which is nothing else, as we observed in its place, but the reguline part of the Butter of Antimony deserted by its Acid.

P R O C E S S IV.

Oils, or Oily matters, that are soluble in Spirit of Wine, separated from Vegetables, and dissolved by means of that Menstruum. Tinctures; Elixirs; Varnishes. Aromatic Strong Waters.

PUT into a matrafs the substances from which you intend to extract a tincture, having first pounded them, or pulverized them if they are capable of it. Pour upon them Spirit of Wine to the depth of three fingers breadth. Cover the matrafs

with a piece of wet bladder, and tie it on with pack-thread. Make a little hole in this bit of bladder with a pin, leaving it in the hole to keep it stopped. Set the matrafs in a sand-bath very gently heated. If the Spirit of Wine dissolve any part of the body, it will accordingly acquire a deeper or lighter colour. Continue the digestion till you perceive that the Spirit of Wine gains no more colour. From time to time pull out the pin, to give vent to the vapours, or rarefied air, which might otherwise burst the matrafs. Decant your Spirit of Wine, and keep it in a bottle well corked. Pour on some fresh Spirit in its stead; digest as before; and go on in this manner, pouring on and off fresh Spirit of Wine, till the last come off colourless.

OBSERVATIONS.

It is commonly said that Spirit of Wine is the solvent of Oils and oily matters: but this proposition is too general; for there are several sorts of Oils and oily matters which this menstruum will not dissolve. Of this number are the Fat Oils, Bee's-Wax, and the other oily compounds of that kind. Properly speaking, it dissolves but two sorts of oily substances; namely, Essential Oils, and Balsams or Resins, which are matters of the same kind, differing from each other only as they are more or less thick; and Oils that are in a saponaceous state.

In our Elements of the Theory we have explained our opinion on this head, from a Memoir on the subject printed among those of the Academy for 1745. To repeat it in a few words: we take the cause of the solubility of Oils in Spirit of Wine to be an Acid, which is but superficially united with them, and so as still to retain its properties.

The principal proofs on which we found this opinion are drawn from that property of Essential Oils, Balsams, and Resins, which are naturally soluble

luble in Spirit of Wine, that they become so much the less soluble in this menstruum, the oftener they are distilled or rectified; and from that property, which Fat Oils, or other Oily matters, naturally indissoluble in Spirit of Wine, possess, of becoming more and more soluble therein the oftener they are distilled. We shewed that distillation lessens the solubility of Essential Oils, Balsams, and Resins, only by depriving these substances of part of the manifest Acid which they contain, and which is the cause of their solubility; and that Fat Oils, and other oily matters, naturally indissoluble in Spirit of Wine, are by the same operation rendered capable of dissolving therein, only because it discovers, and partly extricates, an Acid, which is naturally combined with them so intimately, that it is entirely deprived of action, and all its properties perfectly masked. If these principles be well attended to, and if it be recollected withal, that Spirit of Wine unites with Water preferably to Oils; insomuch that, if it be mixed with water when it hath dissolved an Oil, it quits the Oil to unite with the water; that for the same reason it is not capable, when very aqueous, of dissolving any Oil, seeing that, as Oil and water are not susceptible of contracting any union, it must then desert its phlegm to unite with the Oil; which it cannot do, because it hath a greater affinity with phlegm than with Oil; and, lastly, that if Oil be combined with any saline substance, which makes it soluble in water; that is, if it be in a saponaceous state, it will then remain dissolved in Spirit of Wine, without being precipitated by water, or will be dissolved by a very aqueous Spirit of Wine, and frequently much better than by a highly rectified Spirit: if these things, I say, be considered, we shall easily perceive what must be the effect of digesting Spirit of Wine with any vegetable substance whatever.

Spirit

Spirit of Wine dissolves all the Essential Oil, Balsam, and Resin contained in any vegetable ; and as these matters are not soluble in water, they may be separated from the Spirit in which they are dissolved, by lowering it with much water. It instantly becomes white and opaque, like milk ; the oily parts gradually unite, and form considerable masses, especially if they be resinous. This is the method commonly made use of to extract the Resin of Scammony, Jalap, Guaiacum, and several other vegetable substances ; which it would be difficult to procure by any other means.

If the matters digested with Spirit of Wine contain any saponaceous juices, the Spirit will take up those juices also. But as Soaps are soluble in water, as well as in Spirit of Wine, they cannot be separated, by the addition of water, from the Spirit in which they are dissolved. Whatever quantity of water therefore you mix with a Spirit that is impregnated with such juices, no separation thereof will be produced ; and for the same reason the saponaceous matters will be dissolved by a very aqueous Spirit of Wine.

Spirit of Wine impregnated with such parts of any vegetable substance, as it is capable of dissolving, is commonly called a *Tincture*. Several Tinctures mixed together, or a Tincture drawn from fundry vegetable substances at the same time, and in the same vessel, take the name of an *Elixir*. Tinctures or Elixirs impregnated with Resinous matters only are true *Varnishes*. All these preparations are made in the same manner ; to wit, as directed in our process. We shall only add here that if the substances from which a Tincture or Elixir is to be made contain too much moisture, it is proper to free them from it by a gentle desiccation ; especially if you design that the Tincture should be well impregnated with the oily and resinous parts :
for

for their excess of moisture uniting with the Spirit of Wine would weaken it, and render it unable to act on those matters, which it cannot dissolve when it is aqueous.

Vegetable substances which have been repeatedly digested with different parcels of Spirit of Wine, till the last would extract nothing, are deemed to be exhausted of all their Essential Oils, and saponaceous juices: but if they contain moreover any Fat Oil, Wax, or Gum, these principles will still remain therein after the digestion, in the same quantity as before; because Spirit of Wine is incapable of dissolving them.

With regard to the Fat Oil and Wax, this is not at all surprising: we have explained in another place why these matters are indissoluble by Ardent Spirits: but as for the Gum, it would seem, according to the general principles above-mentioned, that it should be soluble in that menstruum, even with more ease than Resins; as it consists almost entirely of Water, with which Spirit of Wine is known to unite more easily than with Oils. Indeed there is also a little Oil in its composition: but this Oil seems to be in a perfectly saponaceous state; for Gum dissolves wholly and easily in water, without lessening its transparency in the least.

I own that it is extremely difficult to give a very satisfactory account of this matter. We may however venture to throw out some conjectures concerning it, deduced from what hath been already said, relating to the cause of the solubility of Oils in Spirit of Wine. We shewed that the Oils which dissolve in this menstruum derive that property from a manifest Acid, which is united with them but superficially, and in such a manner as to retain all its virtue; but that if this same Acid be too intimately united with the Oil, so as to have no manifest power, but be in a manner destroyed, and converted

as

as it were into a Neutral Salt, it will not then produce this effect.

A modern Author* relates two experiments which agree very well with this opinion, and indeed confirm it. He mixed together Oil of Vitriol and Oil of Turpentine, with a view to imitate by art a bituminous matter; which, we know, is not at all, or at least scarcely, soluble in water. These two matters being united together, produced a red, thick compound, which by evaporation became like a natural Bitumen.

The Author observes that when this mixture is just made it dissolves in Alcohol; but that in some time it changes its nature, and communicates scarce any part of its substance to that solvent. Now whence can such a difference arise, but from this, that when the mixture is new, the Acid is as yet but superficially united with the Oil, and combines with it more and more intimately, as the mixture grows older.

The same Author, having repeated the experiment with Spirit of Vitriol, obtained a compound which continued always very soluble in Spirit of Wine: because Spirit of Vitriol being much weaker and more aqueous than Oil of Vitriol, was incapable of combining so closely with the Oil of Turpentine, as that concentrated Acid did in the former experiment. By the by, there is great reason to believe that the very intimate union of a mineral Acid with an oily matter is the true cause why Bitumens will not dissolve in Spirit of Wine.

It seems therefore pretty probable that the Acid which makes the Oil of Gummy matters soluble in water, and reduces it to a saponaceous state, is so intimately united with that Oil, that it loses its properties,

* Mr. Eadows, in a little English Book, entitled, *The Modern Apothecary*.

ties, and is in a manner converted into a Neutral Salt. Now we know that such Salts are soluble in water, but are not so, for the most part, in Spirit of Wine.

If your Tinctures or Elixirs be not so strong or so saturated as you desire, you may by distillation abstract part of the Spirit of Wine which they contain, and by that means give them such a degree of thickness as you judge proper. But the Spirit of Wine thus drawn off constantly carries along with it a good deal of the aromatic principle. It is a truly *Aromatic Strong Water*. This Spirit of Wine also carries up with it a portion of thin Oil, which is so much the more considerable as the degree of heat employed is greater: and this is the reason why it becomes of a milky colour when mixed with water.

If you intend to make an Aromatic Strong Water only, you need not previously extract a Tincture from the vegetable substance with which you mean to prepare your water: you need only put it in a cucurbite, pour Spirit of Wine upon it, and distill with a gentle heat. By this means you will obtain a Spirit of Wine impregnated with all the odour of the plant.

C H A P. III.

OF TARTAR.

P R O C E S S I.

Tartar analyzed by distillation. The Spirit, Oil, and Alkaline Salt of Tartar.

IN T O a stone retort, or a glass one coated with lute, put some white Tartar broken into small bits; observing that one half, or at least a full third, of the vessel be left empty. Set your retort in a reverberating furnace. Fit on a large ballon, having a small hole drilled in it; lute it exactly with fat lute, and secure the joint with a linen-cloth smeared with lute made of quick-lime, and the white of an egg. Apply at first an exceeding gentle heat, which will raise a limpid, fourish, pungent water, having but little smell, and a bitterish taste.

When this first phlegm ceases to come off, increase your fire a little, and make the degree of heat nearly equal to that of boiling water. A thin limpid Oil will rise, accompanied with white vapours, and with a prodigious quantity of air, which will issue out with such impetuosity, that if you do not open the little hole in the receiver time enough to give it vent, it will burst the vessels with explosion. An acid liquor will rise at the same time. Continue the distillation, increasing the heat by insensible degrees, and frequently unstopping the little hole of the receiver, till the elastic vapours cease to issue, and the Oil to distill.

Then raise your fire more boldly. The acid Spirit will continue to rise, and will be accompanied with

with a black, fetid, empyreumatic, ponderous, and very thick Oil. Urge the fire to the utmost extremity, so that the retort may be of a perfect red heat. This violent fire will raise a little Volatile Alkali, besides a portion of Oil as thick as pitch. When the distillation is finished, you will find in the retort a black, saline, charred matter, which grows hot when wetted, attracts the moisture of the air, runs *per deliquium*, and hath all the properties of a Fixed Alkali.

This mass, being exposed to a naked fire in the open air, burns, consumes, and is reduced to a white ash, which is a fiery, caustic, Fixed Alkali.

OBSERVATIONS.

THE matters qualified to produce a spirituous liquor by fermentation do not all contain the just and accurate proportion of Acid necessary to constitute an Ardent Spirit. Many of them, the juices of fruits for instance, and especially that of the Grape, are replete with a super-abundant quantity of Acid, more than concurs to form that product of fermentation. This super-abundant Acid, combined with some of the Oil and Earth contained in the fermented liquor, produces a sort of Salt, which hangs for a while suspended in that liquor, but after some time, when the Wine stands quiet in a cool place, separates from it, and forms a stone-like incrustation on the inside of the vat in which the Wine is kept. This matter is called *Tartar*.

The Lees of Wine resemble Tartar, in as much as they contain, and yield when analyzed, the same principles; but they differ from it in this, that they contain, moreover, a greater quantity of earth, of phlegm, and a little Ardent Spirit, which are only mixed, but not united with the tartarous Acid.

The residue, or sort of extract, which remains in the cucurbite after Wine hath been deprived of its
Ardent

Ardent Spirit by distillation, hath also a great conformity with Tartar. It even contains that portion of Tartar which remained suspended in the Wine at the time of its distillation: and accordingly this residue of Wine, being analyzed, yields the same principles with Tartar.

Hence we see that liquors, which have undergone the spirituous fermentation, consist of an Ardent Spirit and a Tartarous Acid suspended in a certain quantity of water.

In the analysis of Tartar there are several things worthy of notice. The first is the vast quantity of Air that this mixt body yields when it begins to be decomposed. The chief difficulty attending its analysis arises from this air; which issues out and exerts its elastic force with such impetuosity, that all the precautions above-mentioned, are no more than necessary to prevent the bursting of the vessels.

The singular nature of the thin limpid Oil, which rises with this air, after the first acid phlegm, deserves likewise our particular attention. This Oil is one of the most penetrating we know. Boerhaave, who distilled Tartar without having a vent-hole in his receiver, was obliged, in order to prevent its bursting, to apply it to his retort, with a lute so weak that most of the elastic vapours might perspire through it; and he observed, that, though the neck of his retort entered above five inches into the mouth of his receiver, and was luted on as closely as possible with such a lute, yet this light Oil of Tartar constantly returned back again, as it were, and pervaded the substance of the lute, so that a good deal of it dropped into a dish placed on the outside on purpose to receive it. This Oil is probably rendered so active and subtile, only by having been exceedingly attenuated by the fermenting motion. This experiment is one of those which sufficiently prove the necessity of employing
re-

receivers having a small vent-hole, that may be opened and shut as occasion requires.

The last remark we shall make on the productions of Tartar by distillation, relates to the *caput mortuum* found in the retort when the operation is finished. This residue is very different from that which other vegetable matters afford: for, when they are decomposed in close vessels, they leave nothing but a mere charred matter, in which no saline property appears, and from which no Fixed Alkali can be obtained, but by carrying their analysis to the utmost; that is, by burning them in the open air. Tartar, on the contrary, only by being distilled in close vessels, without burning it afterwards in the open air, is changed into a substance which hath all the properties of a Fixed Alkali. This is probably owing to the Tartar's containing the principles requisite to form a Fixed Alkali in a much greater quantity than they are to be found in any other substance. As Tartar thus alkalized in close vessels still contains much inflammable matter, it might be employed with advantage as a reducing flux in several operations of metallurgy.

Of all the vegetable matters we know, calcined Tartar yields the greatest quantity of Fixed Alkali; which is likewise very pure, and therefore much used in Chymistry.

Burnt Lees of Wine also afford a great quantity of Fixed Alkali, which is of the same nature with that of Tartar. This Salt is used in different trades, and particularly in Dying. The French Vinegar-makers collect quantities of these Lees, which they make up into cakes, and dry: while it is in this state they call it *Gravelle* or *Gravelée*; and *Cenâre Gravelée* when it is burnt.

If the extract of Wine, which remains after the Spirit is drawn off, be gently evaporated to dryness,

and that dry matter burnt like Tartar or *Gravelle*, it will make a sort of *Cendre Gravelée* very rich in alkaline Salt.

PROCESS II.

The Depuration of Tartar. Cream and Crystals of Tartar.

REDUCE to a fine powder the Tartar you intend to purify, and boil it in twenty-five or thirty times as much water. Filter the boiling liquor through a flannel-bag, and then gently evaporate some part of it: there will soon form on its surface a saline crust, which is the *Cream of Tartar*. Let your liquor cool, and there will adhere to the sides of the vessel a great quantity of a crystallized saline matter, which is *Crystal of Tartar*.

OBSERVATIONS.

TARTAR, when taken out of the vats in which it forms, is mixed with a considerable quantity of earthy parts, which are not intimately united therewith, but adulterate it. This extraneous earth makes about two fifths of the whole weight of common Tartar; but white Tartar, which is the best, contains but about a third part of earth.

The method of refining Tartar, and freeing it from this adventitious earth, is very simple, as appears from the process. Earthy matters, which are not intimately combined with an Acid in the form of a Neutral Salt, are not dissoluble in water: for which reason the water, in which crude Tartar is boiled, dissolves the saline part only, which passes with it through the filter; but doth not dissolve the earth of the Tartar, because that earth is not combined

bined with the saline part, and so being only suspended in the liquor remains on the filter.

The saline parts of the Tartar, though they are now separated from the gross earth with which they were mixed, are not yet perfectly pure. These first Crystals of Tartar have a disagreeable russet colour, and are not transparent: this is owing to their being coated over, as it were, with a fatty matter, which also is foreign to their nature, and may be separated from them without decomposing them in the least.

The Crystals of Tartar are but seldom perfectly depurated in Chymical Laboratories; because the operation doth not usually succeed well on small quantities: but there are manufactories which do it by the great, and supply the Chymists, as well as the several tradesmen, with very fine and very pure Crystals of Tartar. These manufactories are chiefly set up in the neighbourhood of Montpellier. Mr. Fises, a celebrated Professor of Medicine, hath in the Memoirs of the Academy for 1725 described the operation as performed in one of these works. He tells us that having separated the earthy part from the Crystals of Tartar, by boiling and filtering, they dissolve them again, and boil them in large caldrons, mixed with a white saponaceous earth, which cleanses and whitens them to perfection.

The saponaceous earth is found near the works; but it is not the only one that may be employed for this purpose: since, as Mr. Fises observed, they have successively made use of several different earths in that very work, and that the earth they now use hath not been long employed. There is reason to think that most saponaceous earths might answer the purpose of refining Crystal of Tartar: but one necessary condition is that they be altogether indissoluble by Crystal of Tartar, which being acid dissolves many sorts of earth; for, if they have not

this quality, they will form a Neutral Salt with the saline part of the Tartar, the nature of which they will entirely change, and convert it into soluble Tartar, as will appear by the experiments that follow.

CHAP. IV.

CRYSTAL OF TARTAR COMBINED WITH SEVERAL SUBSTANCES.

PROCESS I.

*Crystal of Tartar combined with Absorbent Earths.
Soluble Tartars.*

BOIL an Absorbent Earth, such as Chalk, in a pan with water; and, when you perceive the Earth thoroughly divided, and equally distributed through the water, throw into the pan, from time to time, some pulverized Crystal of Tartar, which will excite a considerable effervescence. Continue these projections, till you observe no effervescence excited thereby. All the Absorbent Earth, which obscured the transparency of the water, and gave it an opaque white colour, will gradually disappear as the Crystal of Tartar combines with it; and when the combination is perfected, the liquor will be clear and limpid. Then filter it, and there will be left on the filter but a very small quantity of Earth. Evaporate all the filtered liquor with a gentle heat; and then set it in a cool place to shoot. Crystals will form therein, having the figure of flat quadrangular prisms, with almost always one, sometimes two, of the angles of the prisms shaved down, as it were;
and

and then the surfaces at each end are oblique, answering to those depressed angles. These Crystals are a Neutral Salt, which readily dissolves in water; a true *Soluble Tartar*.

OBSERVATIONS.

CRYSTAL of Tartar is a saline substance of a singular nature. Though it crystallizes like a Neutral Salt, yet it is not one: it hath only the form of one; its principal properties being those of an Acid. Nevertheless it is not a pure Acid; for it is united with a certain quantity of Oil and of Earth, which give it the property of crystallizing, and it is scarce dissolvable in water. It is a middle substance between an Acid and a Neutral Salt. It is an Acid half neutralized; on which account it is capable of acting like an Acid on all substances soluble by Acids, and so of being converted into a perfectly Neutral Salt by combining with them to the point of saturation.

In the experiments made to neutralize Crystal of Tartar, Fixed Alkaline Salts alone were formerly used. Mess. Duhamel and Groffe were the first who discovered that Absorbent Earths might be substituted for Alkalis, and would produce nearly the same effects on Crystal of Tartar. The experiments made by these two Academicians in conjunction are circumstantially related in two curious Memoirs on this subject, given in by them jointly, and printed with those of the Academy for 1732 and 1733. From these Memoirs we took the process here given, and shall borrow from thence most of the remarks we are now going to make.

Stone-lime holds, as it were, the middle place between mere Absorbent Earths and Fixed Alkalis. Now, seeing Crystal of Tartar may be converted into a Neutral Salt by either of these two substances, it follows that Lime ought to produce the same effect

upon it. Accordingly Mess. Duhamel and Groffe found it to be so upon trial; having formed, with *Lac Calcis* and Crystal of Tartar, a Neutral Salt perfectly like that which results from the union of that saline matter with Chalk. *Cremor calcis*, or that salino-terrene pellicle which forms on lime-water, produced the same effect: but, what is most singular is, that lime-water itself, though it be clear and limpid, and consequently doth not seem to contain any earthy particles, produced nevertheless a great effervescence with Crystal of Tartar, and neutralized it as perfectly as *Cremor calcis*, or water ever so much impregnated with Chalk. This arises from hence, that a great quantity of the salino-terrene matter, which forms the *Cremor calcis*, is dissolved in the lime-water.

Though lime-water neutralizes Crystal of Tartar as perfectly as Chalk does, and though the Crystals of Soluble Tartar, or Neutralized Tartar, thereby produced, be like those which have Chalk for their basis, yet Mess. Duhamel and Groffe observed some differences, worthy of notice, between the phenomena accompanying the production of these two Neutral Salts, which resemble each other so much that they seem but one and the same species of Salt. The principal difference consists in this, that the water containing the Tartar neutralized by Chalk is very limpid, and leaves but a very small quantity of earth on the filter: whereas the lime-water, with which Tartar hath been neutralized, leaves on the filter a considerable quantity of earth.

This must appear the more surprising that the water replete with Chalk was, before its union with the Crystal of Tartar, turbid and opaque; whereas the lime-water was at first clear and limpid. Mess. Duhamel and Groffe suspect this to arise from hence, that the effervescence excited, while the Crystal of Tartar dissolves the matter contained in lime-water,

is greater than that which is produced by its union with Chalk suspended in water.

“ If we consider,” say they, “ that in a great effervescence a considerable quantity of the Acid Spirit is evaporated, we shall easily perceive, that, the more of that Spirit escapes, the more of the earth of the Tartar will be precipitated. Now, as the effervescence with lime-water is more considerable, and as there is less alkaline earth to check, as it were, and restrain the Acid, than in the experiment with Chalk, a greater quantity of the acid Spirit may escape; which being entirely lost will cause more earth to precipitate in this case than in the other, where the Acid is all at once attracted by a great deal of alkaline earth: and accordingly this was the reason that our Tartar dissolved by Chalk deposited, in crystallizing, a grey earth, which was scarce perceivable in the experiment made with lime-water.

“ Yet perhaps,” say they, “ an Acid, which we suspect to be contained in Lime, may have partly occasioned the precipitation of this earth.” The existence of this Acid, which these gentlemen at that time only suspected, hath been since demonstrated by several experiments, and particularly by those which Mr. Malouin hath published. This Acid is the Vitriolic, which, in combination with some of the earth of the Lime, forms a sort of Selenitic Salt; which adds greatly to the probability of Mess. Duhamel and Grosse’s last conjecture. I shall now explain how I conceive the Vitriolic Acid in Lime may occasion the copious precipitate which falls in lime-water, when Crystal of Tartar is neutralized by it.

The quantity of Vitriolic Acid contained in Lime is very inconsiderable; so that to convert it into a Neutral Salt requires its intimate union with a very small quantity of the earthy and absorbent

parts. Hence it comes to pass, that, when water is poured upon Quick-lime, in order to make Lime-water, it in some sort divides the Lime into two parts. All the particles of Absorbent Earth, which had not contracted an union with the Acid, are at first barely suspended in the liquor, the transparency of which they destroy, giving it an opaque white colour; and this is what makes the *Lac calcis*: but they soon separate from it, and fall to the bottom, in the form of a precipitate; because they are not soluble in water. By this precipitation the liquor becomes limpid, and remains impregnated only with such of the earthy parts as are united with the Vitriolic Acid, in the form of a kind of Neutral Salt, and have by that union acquired solubility. But the Vitriolic Acid finding many more Absorbent parts in the Lime than were necessary to neutralize it, in a manner over-dosed itself with earthy parts, and thereby exceeded the bounds of a perfect Neutrality.

On the other hand, it hath been shewn that Crystal of Tartar is an imperfect Neutral Salt. Now these two Salts, which are neither of them perfectly Neutral, differ from a perfectly Neutral Salt by properties directly opposite to each other; seeing the Selenitic matter in Lime exceeds in its absorbent or alkaline quality, and Crystal of Tartar exceeds, on the contrary, in acidity.

What must be the consequence, therefore, of mixing these two saline matters together? The same as when an Acid is mixed with a Fixed Alkali; that is, the Salt which exceeds in acidity will combine with the super-abundant alkaline earth of the Selenitic Salt: so that these two saline matters will both become perfectly Neutral Salts. Yet these two Neutral Salts have not the same degree of solubility in water. The neutralized Crystal of Tartar dissolves very readily in water, and is for that reason called

called Soluble Tartar: the Selenitic Salt, on the contrary, is hardly dissolvable in it at all. Now it is a rule that, when two Salts of this nature meet together, the most soluble always remains united with the water, exclusive of the other, which is forced to precipitate. This I imagine to be what happens in the present case; and the precipitate which we see fall, in the lime-water employed to neutralize Crystal of Tartar, seems to me to be no other than the Selenitic Salt of the Lime; which, being less soluble than the neutralized Tartar, gives place to it, and separates from the liquor.

Indeed we cannot, in my opinion, account for the precipitate under consideration, any other way, than by supposing it to be a portion either of the earth of the Crystal of Tartar, or a portion of the Lime. Now, either of these earths is dissolvable by Acids; whereas the precipitate in question, according to the observations of Mess. Duhamel and Grosse, is not so: and this ought to be the case, if the precipitate be nothing but the Selenitic Salt of the Lime, which being a Neutralized Salt, partly constituted by the most powerful of all the Acids, must be unalterable by any Acid whatever.

Mess. Duhamel and Grosse made a great many experiments on the combinations of Crystal of Tartar with different sorts of earths. The result of the whole is, that there are some earths which this Acid dissolves, and which contract such an union with Crystal of Tartar, that they not only change its external character; that is, its tendency to crystallize, and its indissolubleness in cold water, but also entirely alter its taste and other qualities. In a word, those earths produce on this Salt all the effects of alkaline Salts. These earths are such as are called Absorbent Earths: stone-lime, animal-lime, cretaceous earths, a portion of calcined gypsum, and of pot-ash; in short, all such as distilled
vinegar

vinegar is capable of dissolving: this is the mark by which those earths, which are qualified to neutralize Crystal of Tartar, and to render it soluble, may be distinguished.

Mess. Duhamel and Grosse found also upon trial, that there are other earths, on the contrary, which are, in a manner, inaccessible to the Acid of Crystal of Tartar; that they take up, indeed, the grossest and redundant Oil of the Tartar, but without affecting its saline part at all: and if these earths are ever observed to form any union with the Crystals of Tartar, as happens in the refineries near Montpellier, that union is only superficial, not intimate; and therefore it alters none of the characters of the Salt. Among these earths are the clayey, bolar, sandy earths, and others of that kind. Hence Mess. Duhamel and Grosse conclude that these are the earths which ought to be employed in the purification and whitening of Crystal of Tartar. Vinegar is here also the test by which it may be known whether an earth intended for this purpose be fit for it: for you may be sure that it will form no union with Crystal of Tartar, if the Acid of Vinegar be incapable of dissolving it.

PROCESS II.

Crystal of Tartar combined with Fixed Alkalis. The Vegetable Salt. Saignette's Salt. The decomposition of Soluble Tartars.

IN eight parts of water dissolve one part of a very pure alkaline Salt, perfectly freed from the phlogiston by calcination. Heat this lixivium in a stone pan set on a sand-bath, and from time to time throw into it a little powdered Cream of Crystal of Tartar.

Tartar. Each projection will excite a great effervescence, attended with many bubbles, which will rise to a considerable height, one over the other. Stir the liquor when the effervescence ceases, and you will see it begin again.

When no effervescence appears upon stirring the liquor, add a little more Cream of Tartar, and the same phenomena will be renewed. Go on thus till you have obtained the point of perfect saturation.

Then filter your liquor. If the Alkali you made use of was the Salt of Soda, evaporate your liquor quickly to a pellicle, and there will shoot in it crystals of nine sides resembling a coffin; the bottom part thereof being concave, and streaked with a great many parallel lines; and this is *Saignette's Salt*. If you have employed any other Alkali but Soda, or the basis of Sea-salt, evaporate your liquor slowly to the consistence of a syrup: let it stand quiet, and there will form in it crystals having the figure of flatted parallelopipeds; and this is the *Vegetable Salt*, or *Tartarized Tartar*.

OBSERVATIONS.

SEEING pure Absorbent Earths are capable of neutralizing Crystal of Tartar, and converting it into Soluble Tartar, there is still more reason to expect that Fixed Alkalis should possess the same property, as they have a much greater affinity with Acids: and accordingly Crystal of Tartar always forms, with every species of these salts, a Neutral Salt, which is a Soluble Tartar.

A Soluble Tartar, formed by the union of Crystal of Tartar with Tartar converted into an Alkali by fire, hath been long used in medicine as a gentle saponaceous purgative, known by the names of *Tartarized Tartar*, or the *Vegetable Salt*. But the Soluble Tartar, prepared by combining Crystal of Tartar with the Alkali of Soda, which, as we remarked

before, is analogous to the basis of Sea-salt, and different from all other Alkalis, was not well known to Chymists till the year 1731, when M. Boulduc published the preparation in a Memoir printed in the Academy's collection for that year*.

Not but that it was very much used before that time; for it had been for several years in high reputation, and prescribed instead of Tartarized Tartar, which became almost quite neglected. But M. Saignette, a Physician of Rochelle, who was the first inventor and vender of this Salt, did not publish the preparation of it, which he kept as a secret: and this probably contributed not a little to the great esteem which this medicine had acquired: for men are naturally inclined to put a much greater value on secrets, than on what is universally known. He gave it the name of *Sal Polychrestum*; and the public called it also *Saignette's Salt*, and *Rochelle Salt*. Since the discoveries of M. Geoffroy and M. Boulduc were published, the method of preparing this Salt hath been no secret: it was described in Dispensatories, and every Apothecary hath made it ever since.

Saignette's Salt, as well as every other Soluble Tartar, melts when laid on live coals, boils up, emits smoke, and leaves a black charred matter behind. This resemblance of Saignette's Salt to Tartarized Tartar, joined to the smell of the vapour which exhaled in burning it, and is the same with that of Tartar, were the first notices that led M. Boulduc to suppose this Salt to be a Soluble Tartar. On examining the alkaline coal produced by the calcination, and comparing it with that left by Tar-

* It could not be any longer concealed; for M. Geoffroy having made some experiments on the same subject, without knowing any thing of what M. Boulduc had done, likewise discovered it. See the History of the Academy for 1731, p. 35.

arized Tartar, he perceived there was some difference between them. At last his friend, M. Grosse, having advised him, as he tells us in his Memoir, to combine Crystal of Tartar with the Salt of Soda, and to examine the new Salt that would result from their union, M. Boulduc immediately suspected that it must produce a species of Soluble Tartar, which might possibly prove to be the Salt in question. Nor was he mistaken in his conjecture: for with these two saline substances he actually combined a Salt perfectly like Saignette's.

Under the head of Borax we remarked that it contains an Alkali like the basis of Sea-salt. This Alkali is not perfectly neutralized by the sedative Salt, which is also contained in Borax: for its alkaline properties are so perceptible as to have led some Chymists to think that Borax was only an Alkali of a particular kind. This induced M. le Fevre, a Physician at Uzes, and one of the Academy's correspondents, to combine Crystal of Tartar with Borax, and to examine the result. He communicated to the Academy his experiments on this subject; by which he found that the combination of these two saline matters forms a Soluble Tartar, but greatly different from Saignette's Salt; especially in that it doth not crystallize, but remains in the form of a gummy matter, and retains all the Acidity natural to pure Cream or Crystal of Tartar: a circumstance which is very remarkable.

Mr. Lemery had the curiosity to repeat M. le Fevre's experiment, and found that this singular Soluble Tartar had the properties ascribed to it by the inventor. The process he recommends for making the experiment with success is as follows:

“ Take four ounces of Crystal of Tartar finely
 “ pulverized, and two ounces of Borax carefully
 “ powdered, and put these two Salts into a flint-
 “ glass

“ glass body. Pour on them two ounces of water,
 “ and set the cucurbite in a sand-bath. Warm it
 “ with a gentle fire, and then increase the heat so
 “ as to make the liquor boil for a quarter of an
 “ hour; which will produce a perfect dissolution of
 “ the Cream of Tartar and Borax. After the dis-
 “ solution of these two Salts united together, the
 “ liquor will remain clear and limpid, though the
 “ boiling hath dissipated a good deal of it. If the
 “ liquor be still further evaporated, the remainder
 “ will have the consistence of Honey or Turpen-
 “ tine; and if the evaporation be carried still far-
 “ ther, with a gentle heat, the matter remaining will
 “ in colour resemble the gum of a plum-tree, and
 “ yield to pressure as that does; and, if it be exposed
 “ to the air in a damp place, it will grow moist and
 “ run, almost like Salt of Tartar:” a new and sin-
 gular property, which belongs neither to Borax nor
 to Crystal of Tartar, when they are not combined
 together.

All Soluble Tartars are easily decomposed, by
 means of a certain degree of heat. They yield in
 distillation the same principles as Tartar; and the
 Alkali that remains, when they are perfectly cal-
 cined, consists of that which the Tartar naturally
 affords, and of the alkaline matter with which it was
 converted into a Neutral Salt.

These Neutral Salts, resulting from the union of
 Crystal of Tartar with any alkaline matter, are also
 decomposed by all the Acids, even by Vinegar,
 which nevertheless is an Oily Vegetable Acid, and
 consequently of the same kind with Crystal of Tartar.
 The reason of this is, that the Acid of Vinegar, though
 blunted by much phlegm and oil, must be con-
 sidered as a free and pure Acid, when compared with
 Crystal of Tartar, which is still more embarrassed
 with heterogeneous matters, so as to be a semi-
 neutral Salt.

When

When Soluble Tartar is decomposed by an Acid, the Crystal of Tartar, which helped to constitute the Neutral Salt, is then wholly recovered. This saline matter, being separated from that which rendered it soluble in water, ceases now to be so, and for that reason precipitates to the bottom of the liquor.

The Neutral Salts, resulting from the decomposition of Soluble Tartar by an Acid, differ according to the Acid made use of. From Saignette's Salt decomposed by the Vitriolic Acid Mr. Boulduc obtained a true Glauber's Salt, and a precipitate of Crystal of Tartar: and this he justly adduces as a demonstrative proof that Saignette's Salt is no other than Crystal of Tartar neutralized by a Fixed Alkali analogous to the basis of Sea-salt.

Though all Soluble Tartars may be decomposed by Acids, as hath just been said, yet they do not all forsake their bases with equal facility. Mess. Duhamel and Grosse found, that, in this respect, they observe the following order, beginning with those which afford the readiest and most copious precipitate: viz. Soluble Tartar made 1. with Potash; 2. with Chalk; 3. with uncalcined oyster-shells; 4. with Stone-Lime; 5. with calcined oyster-shells; 6. with Salt of Tartar; 7. with Salt of Soda; 8. and lastly, Tartar made soluble with Borax is not precipitated by distilled Vinegar.

It is not easy to account for this difference between Soluble Tartars. If the Salt of Soda were more alkaline than Salt of Tartar, and Borax more alkaline than the Salt of Soda, it might be conjectured that the more alkaline the matters are with which Crystal of Tartar is neutralized, the closer is the union it contracts with them; since it is plain, from what hath been said on this subject, that though Soluble Tartars, which have for their basis Absorbent Earths only, not converted into Lime,
are

are more easily decomposed than those which are rendered soluble by Limes; and these again more easily than those which have a Fixed Alkali for their basis. But, on the contrary, the Salt of Soda is less alkaline than Salt of Tartar, and Borax still less than the Salt of Soda.

P R O C E S S III.

Crystal of Tartar combined with Iron. Chalybeated Tartar. Tincture of Steel with Tartar. Soluble Chalybeated Tartar.

MIX four ounces of Iron, in filings, with one pound of white Tartar finely pulverized. Boil the mixture in about twelve times as much water as you took of Tartar. When the saline part of the Tartar is dissolved, filter the liquor boiling-hot through a flannel-bag, and then set it in a cool place. In a very little time crystals of a russet colour will shoot therein. Decant the liquor from these crystals; evaporate it to a pellicle, and set it again to crystallize. Go on in this manner till it will shoot no more. Collect all the Salt you have thus obtained, and keep it under the name of *Chalybeated Tartar*.

To make the Tincture of Steel with Tartar, mix together six ounces of clean Iron filings, and one pound of white Tartar in powder. Put this mixture into a large iron kettle, and pour thereon as much rain-water as will moisten it. Make a paste of this matter, and leave it thus in a mass for twenty-four hours. Then pour on it twelve pounds of rain-water, and boil the whole for twelve hours at least, stirring the mixture frequently, and adding from time to time some hot water, to supply the place of what evaporates. When you have
thus

thus boiled the liquor, let it stand quiet for some time, and then pour it off from the sediment at bottom. Filter, and evaporate to the consistence of a syrup; and you have the *Tincture of Mars with Tartar*. The Dispensatories generally order an ounce of rectified Spirit of Wine to be poured on this Tincture, in order to preserve it, and to keep it from growing mouldy, as it is very apt to do.

Soluble Chalybeated Tartar is prepared by mixing four ounces of Tartarized Tartar, with one pound of the Tincture of Mars with Tartar, and evaporating them together in an iron vessel to dryness; after which it is kept in a well-stopped phial, to prevent its growing moist in the air.

OBSERVATIONS.

THE three preparations of this process are medicines very well known and much used. There is even reason to think that those, who first thought of combining Tartar in this manner with Iron, had it in their view to prepare compositions useful in medicine, rather than merely to produce new combinations for the improvement of Chymistry. Indeed, were we to consider only the account here given of the manner in which these three compositions are made, we should be inclined to think Crystal of Tartar incapable of dissolving Iron so thoroughly and radically, that, from the union of these two substances, a Neutral Metallic Salt should arise, a Tartar neutralized and made soluble by Iron. For it is very certain that the first of these preparations, which is called Chalybeated Tartar, is nothing but the saline part of Tartar dissolved by boiling water, and then precipitated and crystallized along with particles of Iron, that are reduced, at most, into a rust, or a *crocus* only, but have contracted no union with the Crystal of Tartar; which remains as Acid and as indissoluble after this preparation as

before. Accordingly it is called only *Chalybeated Tartar*, and not *Soluble Chalybeated Tartar*: and, as this latter name hath been given only to the Tartarized Tincture of Mars compounded with Tartarized Tartar; that is, with Tartar rendered soluble by a Fixed Alkali, and not by Iron; there is reason to presume, that the Tincture of Mars alone was not thought worthy of being called a Soluble Chalybeated Tartar; but that the name, importing *Tartar rendered soluble by Mars*, belongs to that Tincture only when compounded with a true Soluble Tartar.

It is nevertheless very certain that the Tincture of Mars made with Tartar contains a true Soluble Chalybeated Tartar; that is, a Neutral Salt consisting of Crystal of Tartar united with Iron, and rendered soluble by that union. The long boiling, necessary to prepare this Tincture, gives the Acid of Tartar time to dissolve the Iron radically, and to unite very closely therewith: but this is not the case in the preparation of Chalybeated Tartar; to make which the Tartar is boiled in water only as long as is necessary for the dissolution of its saline parts; that is, about a quarter or half an hour; in which space the Acid of the Tartar can scarce begin to act on the surface of the Iron: for Acids have not so quick an effect on metals, as on Alkalis and Absorbent Earths. Metallic substances, being vastly more compact, are not near so soon dissolved by Acids, and especially by Vegetable Acids weakened with heterogeneous matters, as the Acid of Tartar is.

I thought the dissolution of Iron by Tartar a point of sufficient importance to deserve a little more attention than hath commonly been given to it; and for that reason resolved to examine, and trace with care, the phenomena observable in this operation.

As the crude Tartar, employed in making the Tartarized Tincture of Mars, is replete with many oily and earthy parts, which cannot but obstruct the dissolution of the Iron, and prevent our seeing clearly how that dissolution is carried on, I thought it better to make use of Cream, or Crystals, of Tartar, which, being pure and freed from all those heterogeneous parts, dissolve in boiling water without prejudicing its transparency.

I therefore pulverized Cream of Tartar, and dissolved as much thereof in boiling water as it would take up. This solution I poured boiling hot into a matrafs, at the bottom of which I had laid some fine Iron wire cut into small pieces. I set the matrafs in a sand-bath; and having heated it so as to make the liquor boil, I observed that, the instant before it boiled, the liquor began to act very perceptibly upon the Iron, in the same manner as other Acids act on metallic substances; that is, there appeared on the surfaces of the little bits of Iron small bubbles, which immediately rose to the surface of the liquor, and succeeded each other so fast, that they formed lines, or jets, seemingly continued from the surface of the Iron to the surface of the liquor, which little by little acquired a faint tinge of yellow.

When the liquor was heated so as to boil, the dissolution still went on, but much more briskly, and the liquor acquired a deeper colour. After boiling about an hour, the liquor, which at first was very clear, became turbid, and of an opaque white; which made me think that some of the Cream of Tartar, dissolved therein, began to precipitate.

I let the whole boil some time longer, and the white precipitate becoming more considerable, I resolved to filter the liquor, which passed through clear, and tinged with a greenish yellow. There remained

on the filter a whitish sediment, which I found to be true Cream of Tartar. The filtered liquor tasted much like a solution of copperas. I evaporated it in a glass basin, set in a sand-heat, but no pellicle appeared; which made me conclude that it would produce no crystals: accordingly having taken some of it out of the basin, when it was considerably reduced by evaporation, and set it in a cool place, no crystal shot in it.

The rest of the liquor I evaporated to dryness: it left a blackish brown residuum, which had the same taste with the liquor before evaporation, but much stronger. This residuum melts very readily in the mouth, without leaving on the tongue the least gritty particle. Being exposed very dry to the air, it grows moist, and runs into a liquor in a very little time. It dissolves easily and readily in a very small quantity of cold water. This solution being mixed with Fixed Alkalis, in various proportions, doth not grow turbid, nor drops any precipitate; but with a decoction of galls it makes ink. Acids give it a much clearer colour, and at first produce no precipitation; but, in a quarter of an hour, there appears a precipitate much of the same colour with the solution. This precipitate is no other than Cream of Tartar, tinged of a ruflet colour by the liquor, which grows turbid, and a little whitish, when the precipitate begins to form.

These experiments, and the circumstances attending them, will not allow us to doubt the truth of what I advanced concerning the Tincture of Mars made with Tartar; viz. that it is nothing but Crystal of Tartar by which Iron is dissolved, and which is rendered soluble by that metal. We see at the very first, that Crystal of Tartar acts upon Iron, just as other Acids do. Indeed this metallic solution is not precipitated by Alkalis: but we know that Alkalis possess the property of dissolving Iron, especially

cially when the metal is previously divided by an Acid; so that there is reason to think this may be the case, when an Alkali is mixed with our Soluble Chalybeated Tartar.

As this Soluble Tartar is a saponaceous and oily Salt, it is also possible that it may be dissolved entirely by the Alkali, without suffering any decomposition; especially as Alkalis decompose Neutral Metallic Salts by means only of the stronger affinity which they have with the Acids, than with the Metals, of which those Salts are compounded. Now, as our Soluble Chalybeated Tartar is compounded of that Metal which the Alkali dissolves with the greatest ease, and of that Acid with which it hath the least affinity of any, it is very possible that it may not have a greater affinity with the Acid than with the metallic basis of this Salt, and so be incapable of decomposing it. However, as this Soluble Chalybeated Tartar makes a black liquor with a decoction of Galls, and as nothing but Iron dissolved by an Acid hath that property, it may be safely concluded that this Salt really consists of Iron dissolved by the Acid of Tartar.

The precipitate which a solution of this Salt lets fall, on the addition of an Acid, is another proof that it consists of these two principles: for this precipitate can be no other than the Tartarous Acid, which, being the weakest of all Acids, is separated from the Iron by the Acid added to the solution; which Acid unites with the martial basis, and forms another Neutral Metallic Salt, according to the Acid employed. Lastly, the great solubility of the desiccated residuum of the Tincture of Mars, made with Tartar, is a very strong and decisive proof, that this residuum is no other than Iron dissolved by the Acid of Tartar: for what else can it be? Nothing but Iron and Crystal of Tartar is made use of in the operation;

tion; and neither of these two substances singly is so soluble as this new body.

We know, moreover, that Crystal of Tartar, which itself is indissoluble, forms a Soluble Tartar when combined with pure Absorbent Earths, though these matters be still more indissoluble than it, or rather, are not soluble at all. Hence it is very natural to conclude that our residuum is a Tartar rendered soluble by Iron. This Chalybeated Tartar is even more soluble than any other sort of Soluble Tartar; for it very readily grows moist in the air, and runs wholly into a liquid; on which account it is not susceptible of crystallization.

I return to one of the circumstances attending my experiment, which it is proper I should account for; though I have hitherto only mentioned it, without more particular notice, that I might not break the connection between facts and the consequences resulting from them. The circumstance I mean is the precipitation of the Cream of Tartar dissolved in the liquor, which, I said, happens when the saline solution hath boiled upon the iron about an hour. This precipitation of the Cream of Tartar may be partly occasioned by the evaporation of the water in which it is dissolved: for the water having taken up, as was said, as much Cream of Tartar as it was capable of dissolving, when the quantity of water comes to be lessened, a proportional quantity of Cream of Tartar must precipitate.

But some other cause must also contribute to produce this precipitation: for, as I boiled my liquor in a matrafs, the evaporation of the liquor could not be considerable, and yet the precipitate was very copious. Moreover, I replenished the matrafs with much more water than was necessary to replace what had evaporated; yet I could not re-
dissolve

dissolve the precipitated Cream of Tartar, nor even sensibly lessen its quantity.

The true cause of this effect I take to be as follows. When the solution of Cream of Tartar hath boiled for some time upon the iron, and dissolved a certain quantity thereof, a proportional quantity of Soluble Chalybeated Tartar is formed. Now as this Salt is much more soluble in water than Cream of Tartar, and as water always takes up the more soluble Salts, preferably to the less soluble, it is not surprising that Cream of Tartar, being one of those saline substances which dissolve with the greatest difficulty, should on this occasion separate from the liquor, and precipitate; yielding its place to a Salt which hath a much greater affinity with water.

Hence it appears that to re-dissolve the Cream of Tartar, and render it capable of continuing to dissolve the Iron as efficaciously as before, it is not sufficient that fresh water be added: but the solution of the Soluble Chalybeated Tartar already formed must be entirely decanted, and fresh water poured on the residue; and then this water, not being impregnated with any Soluble Chalybeated Tartar, will be capable of re-dissolving the Cream of Tartar, and every thing will go on as at the beginning of the operation, till the Cream of Tartar come to precipitate again, for the same reason as before, and make a repetition of the same management necessary. The liquor is far from being saturated with Soluble Chalybeated Tartar, when the precipitation of the Cream of Tartar renders it necessary to decant it: so that the water must be often renewed, if you carry the operation to the utmost; and then all these solutions must be added together, and evaporated, either to dryness, if you desire to have the Salt in a dry form, or to any other degree you think proper.

This method I followed at first : but as it is exceeding long and tedious, though perhaps the best ; and as I wanted to have a moderate quantity of Soluble Chalybeated Tartar, with less trouble, and in less time, if possible, I resolved to try whether or no Cream of Tartar, though separated from the liquor and undissolved, were still capable of acting on the Iron with such efficacy as to dissolve it. I therefore continued to boil the tartarous solution on the filings of Iron, notwithstanding the precipitation of the Cream of Tartar, taking care only to add fresh water from time to time, as directed in the process for the Tartarized Tincture of Mars, to replace what evaporated ; and I observed that, in fact, the Cream of Tartar, though not perfectly dissolved, but only divided and agitated by the motion of boiling, still continued to act upon the Iron ; so that the liquor, after boiling seven or eight hours, was so impregnated as to yield by evaporation a reasonable quantity, in bulk, of Salt in a dry form.

P R O C E S S I V .

Crystal of Tartar combined with the reguline part of Antimony. Stibiated or Emetic Tartar.

PULVERIZE and mix together equal parts of the Glass and of the Liver of Antimony. Put this mixture, with the same quantity of pulverized Cream of Tartar, into a vessel capable of containing as much water as will dissolve the Cream of Tartar. Boil the whole for twelve hours, from time to time adding fresh water, to replace what is dissipated by evaporation. Having thus boiled your liquor, filter it while boiling hot ; evaporate to dryness ;

dryness; and you will have a saline matter, which is *Emetic Tartar*.

OBSERVATIONS.

THE Glass and Liver of Antimony are no other, as was said in its place, than the metallic earth of Antimony separated from the redundant Sulphur of that mineral; but still retaining such a quantity of phlogiston as to possess, excepting its metalline colour, nearly the same properties with Regulus of Antimony, and especially its Emetic quality, and its solubility in Acids. Indeed these two preparations seem to have more of an Emetic quality than the Regulus itself, and therefore are employed preferably to all others in the preparation of Emetic Tartar.

It is not yet ascertained in which of the principles of Antimony its Emetic virtue resides. We are sure however that it cannot be ascribed to its earthy part: for the calx of Antimony, when entirely deprived of all phlogiston, is not Emetic, nor even purgative; as is evident from the effects of Diaphoretic Antimony and the Pearly Matter.

Some Authors think Antimony contains an Arsenical principle, to which they impute its Emetic quality: nor is their opinion altogether void of probability. For this arsenical part seems to be indicated by several of the properties of Antimony, and particularly by its affinities with other metallic substances, in which it very nearly resembles Arsenic. But this doth not amount to a positive proof: for we can draw nothing but probable conjectures at most, from such analogies.

Other Chymists think the Emetic virtue of Antimony depends on the union of its metallic earth with its phlogiston. This opinion seems to me much more probable than the other: for by only re-combining a phlogiston with the earth of Antimony, deprived

deprived by calcination of all its Emetic virtue, that virtue is perfectly restored, and the Regulus thus revived is no less Emetic than that which never underwent calcination.

However this be, it is certain that Cream of Tartar acquires an Emetic quality, not by barely uniting with one of the principles of Antimony, but by dissolving entirely the reguline, or semi-reguline, part thereof: and that its Emetic quality is so much the stronger, the more of that substance it hath dissolved. This is the result of several experiments made on the subject by Mr. Geoffroy.

That gentleman collected several parcels of Emetic Tartar, having different degrees of strength. "I employed," says he*, "an ounce of each of those Emetic Tartars: I rubbed them separately with an equal weight, or something more, of a black flux, made of two parts of red Tartar and one part of Nitre calcined together. These mixtures I put into different crucibles, formed like inverted cones: I kept them in a melting heat till the Salts in fusion sunk, and appeared like a smooth Oil at the bottom of each crucible. I then let the fire go out, broke the crucibles when cold, and found the resuscitated Regulus in a mass at bottom.

"Out of one ounce of the weakest Emetic Tartars I obtained from thirty grains to one dram eighteen grains of Regulus. From one ounce of such as were of a middling strength I got one dram and an half; and the most violent yielded me two drams and ten grains.

"The power therefore of the strongest Emetic Tartars," continues he, "depends on the quantity of Regulus of Antimony dissolved by the Cream of Tartar, and the nearer the preparations of

* Memoirs of the Academy for 1734, p. 421.

"Antimony;

“ Antimony, on which the solution of Cream of
 “ Tartar is boiled, are to the form of a Regulus or
 “ a Glass, the more violent is the Emetic Tartar;
 “ because the Vegetable Acid of the Tartar acts
 “ then more immediately upon the Emetic part of
 “ the Antimony, and dissolves more of it.”

Mr. Geoffroy found upon trial that Cream of Tartar boiled for a due time on crude Antimony, doth indeed dissolve a little of the reguline part thereof; but that the quantity of Regulus dissolved thereby is so very small, that the Emetic Tartar produced is extremely weak. The gross Sulphur, in this case, hinders the Cream of Tartar from acting on the reguline part with so much efficacy, as when the Antimony is properly prepared by freeing it entirely from its redundant Sulphur.

Nothing can be added to what Mr. Geoffroy hath said on this subject. His experiments are decisive, and set the truth he intended to prove in the clearest light.

Mr. Hoffman affirms that Emetic Tartar loses part of its virtue by being boiled too long. A very able Chymist goes so far as to say that Tartar ought not to boil above six or seven minutes with prepared Antimony; because longer boiling destroys part of its Emetic quality. Can this arise from hence, that Cream of Tartar, after dissolving a certain quantity of the reguline substance, separates from it afterwards? Or is the Cream of Tartar itself decomposed by too long boiling? This deserves to be particularly enquired into, as well as the nature of the Metallic Salt, which results from the union of the Acid of Tartar with the Regulus of Antimony.

Crystal of Tartar acts also on several other metallic substances, and particularly on Lead; with which it forms a Salt, resembling Tartarized Tartar in the figure of its Crystals.

CHAP. V.

OF THE PRODUCT OF ACETOUS FERMENTATION.

PROCESS I.

Substances susceptible of the Acetous Fermentation turned into Vinegar.

THE Wine, the Cyder, or the Malt-liquor, which you intend to convert into Vinegar, being first thoroughly mixed with its lees, and with the Tartar it may have deposited, put your liquor into a vat used before, either for making or for holding vinegar. This vessel must not be quite full, and the external air must have access to the liquor contained in it. Set it where the air may have a degree of warmth answering nearly to the twentieth degree above 0 in Mr. de Reaumur's Thermometer. Stir the liquor from time to time. There will arise in it a new fermentative motion, accompanied with heat: its vinous odour will gradually change, and turn to a sour smell, which will become stronger and stronger, till the fermentation be finished, and cease of itself. Then stop your vessel close; the liquor it contains will be found converted into Vinegar.

OBSERVATIONS.

ALL substances that have undergone the spirituous fermentation, are capable of being changed into an Acid, by passing through this second fermentation, or this second stage of fermentation. Spirituous liquors, such as Wine, Cyder, Beer, being exposed

to

to a hot air, grow sour in a very short time. Nay, these liquors, though kept with all possible care, in very close vessels, and in a cool place, degenerate at last, change their natures; and insensibly turn sour. Thus the product of spirituous fermentation naturally and spontaneously degenerates to an Acid.

For this reason it is of great importance, in making Wine, or any other vinous liquor, to stop the fermentation entirely, if you desire the Wine should contain as much Spirit as possible. It is even more advantageous to check the fermentation, a little before it comes to the height, than afterwards: because the fermentation, though slackened, and in appearance totally ceased, still continues in the vessels: but in a manner so much the less perceptible, as it proceeds more slowly. Thus those liquors, in which the fermentation is not quite finished, but checked, continue for some time to gain more Spirit: whereas, on the contrary, they degenerate and gradually turn sour, if you let the spirituous fermentation go on till it be entirely finished.

The production of the second fermentation, which we are now to consider, is an Acid of so much the greater strength, the stronger and more generous the spirituous liquor, in which it is excited, originally was. The strength of this Acid, commonly called *Vinegar*, depends likewise in a great measure on the methods used in fermenting the vinous liquor, in order to convert it into Vinegar: for if it be fermented in broad, flat vessels, and left to grow sour of itself, the spirituous part will be dissipated, and the liquor, though sour indeed, will be vapid and effete.

The Vinegar-makers, to increase the strength of their Vinegar, use certain methods of which they make a mystery, keeping them very secret. However, Mr. Boerhaave gives us, from some Authors, the

the following description of a process for making Vinegar.

“ Take two large oaken Vats or Hogsheds, and
“ in each of these place a wooden grate or hurdle,
“ at the distance of a foot from the bottom. Set the
“ vessel upright, and on the grates place a moderately close layer of green twigs, or fresh cuttings
“ of the vine. Then fill up the vessel with the foot-
“ stalks of grapes, commonly called the *Rape*, to
“ within a foot of the top of the vessel, which must
“ be left quite open.

“ Having thus prepared the two vessels, pour
“ into them the Wine to be converted into Vinegar,
“ so as to fill one of them quite up, and the other
“ but half-full. Leave them thus for twenty-four
“ hours, and then fill up the half-filled vessel, with
“ liquor from that which is quite full, and which
“ will now in its turn be left only half full. Four
“ and twenty hours afterwards repeat the same operation,
“ and thus go on, keeping the vessels alternately full and half full, during every twenty-four
“ hours, till the Vinegar be made. On the second
“ or third day there will arise, in the half-filled
“ vessel, a fermentative motion, accompanied with
“ a sensible heat, which will gradually increase from
“ day to day. On the contrary, the fermenting
“ motion is almost imperceptible in the full vessel,
“ and as the two vessels are alternately full and
“ half full, the fermentation is by that means in
“ some measure interrupted, and is only renewed,
“ every other day, in each vessel.

“ When this motion appears to be entirely ceased,
“ even in the half-filled vessel, it is a sign that the
“ fermentation is finished; and therefore the Vinegar
“ is then to be put into common casks close
“ stopped, and kept in a cool place.

“ A greater or less degree of warmth accelerates
“ or checks this, as well as the spirituous fermentation.
“ tion.

“ tion. In France it is finished in about fifteen days,
 “ during the summer; but if the heat of the air be
 “ very great, and exceed the twenty-fifth degree of
 “ Mr. de Reaumur’s Thermometer, the half-filled
 “ vessel must be filled up every twelve hours; be-
 “ cause if the fermentation be not so checked in
 “ that time, it will become so violent, and the
 “ liquor will be so heated, that many of the spiritu-
 “ ous parts, on which the strength of the Vinegar
 “ depends, will be dissipated; so that nothing will
 “ remain, after the fermentation, but a vapid wash,
 “ sour indeed, but effete. The better to prevent the
 “ dissipation of the spirituous parts, it is a proper
 “ and usual precaution to close the mouth of the
 “ half-filled vessel, in which the liquor ferments,
 “ with a cover made also of oak-wood. As to the
 “ full vessel, it is always left open, that the air may
 “ act freely on the liquor it contains: for it is not
 “ liable to the same inconveniences, because it fer-
 “ ments but very slowly.”

The vine-cuttings and grape-stalks, which the
 Vinegar-makers put into their vessels, serve to
 increase the strength of the liquor. These matters
 contain a very manifest and perceptible Acid. They
 also serve as a ferment; that is, they dispose the
 Wine to become eager more expeditiously and
 more vigorously. They are the better, and the
 more efficacious, for having been once used, be-
 cause they are thereby thoroughly drenched with the
 fermented Acid: and therefore the Vinegar-makers
 lay them by, for preparing other Vinegar, after
 washing them nimbly in running water, in order
 to free them from a viscid oily matter, which settles
 on them during the fermentation. This matter
 must by all means be removed; because it is dis-
 posed to grow mouldy and rot; so that it cannot
 but be prejudicial to any liquor into which you
 put it.

As

As the Acetous fermentation differs from the Spirituous in its production, so it doth in many circumstances attending it. 1. Motion and agitation are not prejudicial to the Acetous fermentation, as they are to the Spirituous; on the contrary, moderate stirring, provided it be not continual, is of service to it. 2. This fermentation is accompanied with remarkable heat; whereas the warmth of the Spirituous fermentation is scarce sensible. 3. I do not believe there ever was an instance of the vapour that rises from a liquor in Acetous fermentation proving noxious, and producing either disorders or sudden death, as the vapour of fermenting Wine doth. 4. Vinegar deposites a viscid oily matter, as hath just been observed, very different from the Lees and Tartar of Wine. Vinegar never deposites any Tartar; even though new Wine, that hath not yet deposited its Tartar, should be used in making it.

The following processes will give us occasion to treat of the nature of Vinegar, and the principles of which it consists.

PROCESS III.

To concentrate Vinegar by Frost.

EXPOSE to the air, in frosty weather, the Vinegar you desire to concentrate. Icicles will form in it; but the whole liquor will not freeze. Take out those icicles; and if you desire a further concentration of your Vinegar by this method, the liquor which did not freeze the first time must be exposed to a stronger frost. More icicles will form therein, which must likewise be separated, and kept by themselves. The liquor which doth not freeze this second time will be a very strong concentrated Vinegar.

OBSERVE-

OBSERVATIONS.

LIQUORS, replete with an Acid, freeze with much more difficulty than pure water. Thus, if a very aqueous acid liquor be exposed to frost, some of the water in the liquor will presently freeze; while the rest, being rendered more acid by the separation of the frozen phlegm, will remain fluid, and resist the degree of cold which freezes water. Now Vinegar, being an acid liquor containing much water, may therefore be highly concentrated by freezing its phlegm in this manner; and the more icicles you get from it, the stronger and more active will the remaining Vinegar be.

Mr. Stahl was the first, I believe, who thus made use of congelation, for procuring a very strong Acid of Vinegar. Mr. Geoffroy hath since taken the same method. A curious and circumstantial account of his experiments, on this subject, are printed in the *Memoirs of the Academy* for 1739.

As it was excessive cold in the winter of that year, Mr. Geoffroy took the opportunity of exposing to the frost several Vinegars of different strengths; and he determined the degree of acidity in each, both before and after their concentration, in order to compare them, and discover how much stronger each Vinegar was rendered by the freezing of the aqueous part. To determine the strength of the Vinegars, he made use of the method pointed out by Mr. Homberg and Mr. Stahl. This method consists in combining to the exact point of saturation, a certain quantity of Vinegar with well-dried Salt of Tartar. The more Salt of Tartar is required, to absorb and perfectly neutralize the Vinegar, the stronger it must be reckoned; because the quantity of Alkali necessary to constitute a Neutral Salt is always proportioned to the quantity of Acid in that Salt.

One of the Vinegars employed in Mr. Geoffroy's experiments, two drams of which were entirely absorbed by six grains of Salt of Tartar, having been concentrated by once freezing, and thereby reduced from eighteen quarts to six, he found it so increased in strength, that two drams thereof required twenty-four grains of Salt of Tartar to absorb them.

The first icicles that separate from Vinegar in this process, are perfectly clear, and as insipid as water. As the Vinegar becomes more concentrated, the plates of ice becoming thinner, more spongy, and flaky like snow, retain between them some portion of the Acid; and it is proper to begin to save them as soon as they appear to be sensibly acid.

Mr. Geoffroy carried the concentration of Vinegar as far as the cold of that winter in 1739 would allow him; and eight quarts of Vinegar, already concentrated by frost in the preceding years, being reduced to two quarts and a half by the frost of the 19th of January, the coldest day of that year, was found to be so strong, that two drams thereof required forty-eight grains of Salt of Tartar to absorb them. The icicles of this Vinegar, being thawed, retained so much strength as to require thirteen grains of the Salt of Tartar to absorb them.

Vinegar suffers no decomposition by the congelation of its phlegm, and the consequent concentration of its Acid. What is left still contains all the principles of which Vinegar consists. Its principles are only brought nearer together, and into a smaller compass: and for this reason it grows the thicker, the more it is concentrated. When therefore you desire to concentrate the Acid of Vinegar, and at the same time to purify it, that is, to free it from some of its oil and earth, you must have recourse to distillation.

Wine, as well as Vinegar, may be concentrated by freezing. Mr. Stahl exposed several sorts of
Wine

Wine to the frost, and by that means separated from them about two-thirds, or three-quarters, of almost pure phlegm. The remainders of the Wines so concentrated were of a somewhat thickish consistence. They were very strong, and kept for several years without altering, in places where the free access of the air, alternately cold and hot according to the seasons, would have soured, or spoiled, any other kind of Wine in the space of a few weeks.

Wine thus concentrated by freezing, is not thereby decomposed, any more than Vinegar: it is only dephlegmated. By the addition of as much water as was separated from it, you may restore it to its former condition; in which respect it differs greatly from the residue of Wine whose spirituous part, with a proportion of its phlegm, hath been drawn off by distillation: for though you mix that residue again with the principles you separated from it, you can never make Wine of it again; the spirituous part being no longer in a capacity to combine with the other principles of the Wine, in the same manner as before that separation. And this shews that heat, besides separating the most volatile parts, produces moreover a considerable change in the disposition of those which did not rise in the first distillation.

Since the above experiments were made by Mess. Stahl and Geoffroy, concentration by freezing is pretty frequently practised in laboratories; but on Vinegar only, seldom on Wine; because, when Vinegar is thus concentrated, a much stronger Acid is more easily and more expeditiously obtained from it, as will be shewn in the following process; whereas the distillation, as well as the quality, of Spirit of Wine is much the same, whether the Wine it is obtained from be concentrated or no. The reason of this difference is, that Spirit of Wine, being very

light, rises in distillation before the phlegm; whereas the Acid of Vinegar, being much more ponderous, rises only at the same time with the aqueous part, or even after it.

P R O C E S S III.

Vinegar analyzed by Distillation.

INTO a glass or stone cucurbite put the Vinegar to be distilled; fit to it a glass head; place your alembic in the sand-bath of a distilling furnace, and lute on a receiver. Apply a very gentle heat at first. A clear, limpid liquor will rise, and fall in distinct drops, like water, from the nose of the alembic.

Continue distilling this first liquor, till the Vinegar contained in the cucurbite be diminished about a fourth part. Then shift your receiver, and increase the fire a little. A clear liquor will still come over, but heavier and more Acid than the former. Distill in this manner, till you have drawn off into your second receiver, two-thirds of the liquor that was left in the cucurbite.

A thick matter will now remain at the bottom of the still: put it into a retort; lute on a receiver; set your retort in a reverberating furnace, and distill with degrees of fire. There will come over a limpid liquor, very acid and sharp, yet ponderous, and requiring a great degree of fire to raise it; on which account it makes the receiver very hot. It hath a strong empyreumatic smell. When the distillation begins to slacken, increase your fire. There will arise an Oil of a fetid, quick smell. At last, when nothing more will rise with the strongest fire, break the retort, and in it you will find a black charred

charred matter: burn it, and from the ashes lixiviated with water you will obtain a Fixed Alkali.

OBSERVATIONS.

NONE of the liquors that come over in this operation, before the last fetid Oil, seem to have any other properties than those of an oily Acid; none of them are inflammable; none of them resemble Spirit of Wine; but all of them being thrown into the fire extinguish it. Mr. Boerhaave however takes notice that a Chymist, named Vigani, affirms the first portion of the liquor which rises in the distillation of Vinegar to be inflammable, and no other than Spirit of Wine. Mr. Boerhaave suspected that this might happen from Vigani's having distilled Vinegar too newly made; and found upon trial that Vinegar, being distilled soon after it was made, yielded at first in distillation a certain quantity of an Ardent Spirit; but that the same thing did not happen in the distillation of old Vinegar. And this proves that fermentation hath the same effect on Vinegar as on Wine; that is, that though the fermentation which produces these liquors seems to be over in a certain time, when the violent intestine commotion ceases, yet it still continues in the vessels for a considerable time after, though it be imperceptible. Thus, the portion of Ardent Spirit, obtained from some Vinegars, comes from a small quantity of Wine, which still remains unchanged in these Vinegars, not having had time enough to turn sour. For it is certain, from the experiments of all other Chymists as well as Mr. Boerhaave, that Vinegar, when old enough, yields no Ardent Spirit in distillation.

But though old and well-made Vinegar yields no Ardent Spirit in distillation, we cannot thence conclude that it contains none. On the contrary, there are experiments which demonstrate that some of the

Ardent Spirit, which was in the Wine before it was turned into Vinegar, still remains ; but probably so combined and blended with the acid part, that it cannot be separated and rendered perceptible but by peculiar processes.

Mr. Geoffroy obtained an Ardent Spirit from Vinegar, by distilling it as soon as it was concentrated by freezing. " This Spirit," says he*, " is
 " the first liquor that rises. At first it hath only
 " the same degree of inflammability as brandy ; but,
 " when re-distilled in the *balneum marie*, it fires
 " gun-powder, like the best rectified Spirit of
 " Wine ; with this difference, that our Spirit is im-
 " pregnated with an Oil of an acrid taste and em-
 " pyreumatic smell, which makes it yellow, and
 " imparts its odour to it. This Spirit, at least that
 " which comes over first, retains none of the Acid
 " of the Vinegar ; seeing it neither changes the
 " Tincture of Violets, nor effervesces with Salt of
 " Tartar."

Mr. Geoffroy observes, that if Vinegar, concentrated by freezing, be afterwards kept for several years, no Ardent Spirit will then be obtained from it by distillation. And this confirms what we said of unconcentrated Vinegar, and gives reason to think that the Ardent Spirit obtained from Vinegar, either by distilling it after concentration by freezing, or by other processes, of which we shall treat in the sequel, is foreign to the Vinegar, and is only found therein, as was said above, because Vinegar contains a certain quantity of Wine which hath not altered its nature. For the Spirit of Wine we obtain from Vinegar doth not hinder our obtaining from it a great deal of Acid, which being more ponderous rises after it. Mr. Geoffroy gives the following account of the sequel of his analysis of Vinegar by distillation.

" Con-

“ Continuing to distill in a *balneum mariæ* the
 “ concentrated Vinegar, of which I had employed
 “ four pounds two ounces, there was left, after the
 “ distillation, a residuum of fourteen ounces; which
 “ could not rise, because it was too thick. I found
 “ it covered with a saline crust, which is the true
 “ Essential Salt of Vinegar, and not of the same
 “ nature with Tartar: for Tartar of Wine is scent-
 “ less; whereas the Salt of Vinegar hath a pungent
 “ smell, being the Acid of Tartar subtilized by its
 “ union with the Sulphureous parts. If a sand-bath
 “ be now used, instead of the *balneum mariæ*, to
 “ carry on the distillation without burning the
 “ matter, part of this Salt will be resolved, and yield
 “ the last Acid Spirit, which is the strongest that
 “ can be obtained.

“ After I had, by a sand-heat, extracted all the
 “ Acid Spirit that the several residuums put toge-
 “ ther would yield, I found at the bottom of the
 “ cucurbite a brown mass, of the consistence of a
 “ pretty solid extract. Of this I put into a retort
 “ two pounds, together with six pounds of sand
 “ well washed and very dry; and, applying a gra-
 “ duated heat, I first obtained six ounces of an
 “ Acid Spirit, that smelt very strong of the empy-
 “ reuma, and was a little coloured with some portion
 “ of Oil: seven ounces of Spirit, having a volatile
 “ urinous smell, came over next: at last the white
 “ vapours appeared more and more dense. A vola-
 “ tile concrete Salt adhered to the sides of the
 “ ballon, and I found four ounces of a thick fetid
 “ Oil floating on the Spirit. The concrete volatile
 “ Salt, when collected, weighed two drams. The
 “ black matter remaining in the bottom of the
 “ retort, being calcined and lixiviated, yielded a
 “ fat alkaline Salt, which it is almost impossible to
 “ dry.”

I have given this account of Mr. Geoffroy's analysis of Vinegar at length, only because it differs in several respects from that described in the process, which is Mr. Boerhaave's, as well as from those delivered by several other authors, who make no mention either of the saline matter, which Mr. Geoffroy found on the residuum of Vinegar, after its first distillation in the *balneum mariæ*, or of the volatile urinous Spirit and Salt, which he obtained from that residuum.

These differences may arise either from the manner of distilling the Vinegar, or from Mr. Geoffroy's Vinegar having been concentrated by freezing, or rather, from the quantity, and, above all, from the age of the Vinegar, examined by those different Chymists.

The distillation of Vinegar serves not only to separate its Acid from a considerable quantity of earth and oily parts, with which it is entangled, but also to dephlegmate and concentrate it. Yet Mr. Lemerî affirms that Vinegar is not distilled with a view to dephlegmate it. He condemns the common method of throwing away the first runnings as useless phlegm, and saving only what comes off afterwards; having, he says, observed that the phlegm of Vinegar cannot be abstracted, like that of many other acid liquors, and that what comes over first is almost as sharp as what rises afterwards, be the fire applied at first ever so small.

There is reason to think that Mr. Lemerî did not carefully enough examine the strength of his Spirit of Vinegar, at the different stages of his distillation: for Mr. Geoffroy, in the Memoir above cited, gives an account of a distillation of Vinegar, the product whereof he examined with care, having for that purpose divided it into five different portions: and his experiments put it beyond all doubt, that the
first

first portions of Spirit of Vinegar are far from being so acid as the last. This Vinegar was so strong before distillation, that it required six grains of Salt of Tartar to absorb two drams of it. Two drams of the first portion of his Spirit were absorbed by three grains only of Salt of Tartar: the Acid of the second portion took five grains to absorb it. (Each experiment was made with two drams of Vinegar.) The third portion was absorbed by ten grains; the fourth by thirteen, and the fifth took no less than nineteen: which proves that Vinegar, like most other Acids, may be concentrated by distilling off the most aqueous part, which is lighter than the Acid.

There are therefore two ways of concentrating Vinegar, and separating its most acid part, namely, distillation and congelation. These two methods may be successively applied to the same Vinegar, and a very powerful Acid obtained by their concurrence. Mr. Geoffroy, having exposed to the frost, on the 19th of January 1739, the last russet coloured liquor, drawn from the residuum of distilled Vinegar, found it so concentrated thereby, that it required sixty grains of Salt of Tartar to absorb two drams of it.

C H A P. VI.

THE ACID OF VINEGAR COMBINED WITH DIFFERENT SUBSTANCES.

P R O C E S S I.

*The Acid of Vinegar combined with alkaline substances.
Foliated Salt of Tartar, or Regenerated Tartar.
Decomposition of that Salt.*

INTO a glass cucurbite put some very pure and well-dried Salt of Tartar; and pour on it some good distilled Vinegar, by little and little at a time. An effervescence will arise. Pour on more Vinegar, till you attain the point of saturation. Then fit a head to the cucurbite; set it in a sand-bath; and having luted on a receiver, distill with a gentle heat, and very slowly, till nothing remain but a dry matter. On this residuum drop a little of the same Vinegar; and if any effervescence appears, add more Vinegar till you attain the point of saturation, and distill again as before. If you observe no effervescence, the operation was rightly performed.

O B S E R V A T I O N S.

It is not easy to hit the exact point of saturation in preparing this Neutral Salt; because the oily parts, with which the Acid of Vinegar is loaded, hinder it from acting so briskly and readily as it would do, if it were as pure as the Mineral Acids: and for this reason it often happens, that, when we have nearly attained the point of saturation, the addition of an Acid makes no sensible effervescence, though

though the Alkali be not yet entirely faturated; which deceives the operator, and makes him conclude erroneously, that he hath attained the true point of saturation.

But he easily perceives his mistake, when, after having separated from this saline compound all its superfluous moisture by distillation, he drops fresh Vinegar upon it: for then the Salts being more concentrated, and consequently more active, produce an effervescence, which would not have been sensible, if this last portion of Acid, instead of coming into immediate contact with the dried Alkali, could not have mixed therewith till diffused through, and in a manner suffocated by, that phlegm from which the Acid of the Vinegar, before neutralized, was gradually separated by its combining with the Alkali; that phlegm keeping in solution both the Neutral Salt already formed and the Alkali not yet saturated. And for this reason it is necessary to try, after the first desiccation of this Salt, which is called *Regenerated Tartar*, whether or no the just point of saturation hath been attained.

It may also happen, that, though the point of saturation was exactly hit at first, this compound Salt shall nevertheless, after desiccation, effervesce with fresh Vinegar, and therefore not be in a perfectly neutral state at that time. In this case the Salt must have been dried by too violent a fire, and partly decomposed by an excess of heat carrying off some of the Acid, which doth not adhere very strongly to the Alkali. This is one of the reasons why it is necessary that *Regenerated Tartar* be desiccated with a very gentle heat.

From what hath been said, concerning the desiccation of this Neutral Salt, it is plain that the use of it is only to free the Salt from the great quantity of superfluous moisture wherein it is dissolved: which proves that the Acid of Vinegar, like all other
Acids

Acids dissolved in much water, is separated from most of this redundant phlegm by being combined with a Fixed Alkali. And hence we must conclude that the Acid of Vinegar, contained in Regenerated Tartar desiccated, is vastly stronger and more concentrated than it was before: and accordingly Mr. Geoffroy, having decomposed this Salt, by the means of concentrated Oil of Vitriol, obtained a Spirit of Vinegar in white vapours, which was very volatile and very strong, but perhaps somewhat depraved with a taint of the Vitriolic Acid.

Though the Acid of Vinegar be freed, by combining with a Fixed Alkali, from a great quantity of superfluous phlegm, as was shewn above; yet the oily parts with which it is entangled still cleave to it: these parts are not separated from it by its conversion into a Neutral Salt, but, without quitting it, combine also with the Fixed Alkali; and this gives Regenerated Tartar a saponaceous quality, and several other peculiar properties.

Regenerated Tartar, when dried, is of a brown colour. It is semi-volatile; melts with a very gentle heat, and then resembles an unctuous liquor; which indicates its containing an Oil: when cast upon live coals, it flames; and, when distilled with a strong heat, yields an actual Oil; all which evidently prove the existence of that Oil.

This Salt is soluble in Spirit of Wine; a quality which it probably owes also to its Oil. It requires about six parts of Spirit of Wine to dissolve it; and the dissolution succeeds very well in a matrafs, with the help of a gentle warmth. If the Spirit of Wine be abstracted from this solution, by distilling with a small fire, the Salt remains at the bottom of the cucurbite, in the form of a dry substance composed of leaves lying one upon another; which hath procured it the name of *Terra Foliated Tartari*, or *Foliated Salt of Tartar*.

It is not absolutely necessary that Regenerated Tartar be dissolved in Spirit of Wine to make the Foliated Salt: for it may be procured in this form, by only evaporating the water in which it is dissolved. But the operation succeeds better with Spirit of Wine; probably because the success thereof depends on using an exceeding gentle warmth: now Spirit of Wine evaporates with much less heat than water.

Regenerated Tartar may also be crystallized. If you desire to have it in this form, combine the Acid with the Alkali to the point of saturation; evaporate the liquor slowly to the consistence of a syrup, and set it in a cool place; where it will shoot into clusters of crystals lying one upon another like feathers.

Vinegar perfectly dissolves absorbent matters also, and particularly those of the animal kingdom; such as Coral, Crabs-eyes, Pearls, &c. In order to a dissolution of such matters, you must pulverize them, put them into a matrafs, and pour on them Spirit of Vinegar to the depth of four fingers breadth: an effervescence will arise; when that is over, set the mixture to digest two or three days in a sand-bath; then decant the liquor, filter it, and evaporate it to dryness with a very gentle heat. The matter which remains is called *Salt of Coral, of Pearls, of Crabs-eyes, &c.* according to the substances dissolved. If, instead of evaporating the liquor, a Fixed Alkali be mixed therewith, the absorbent matter, that was dissolved by the Acid, will precipitate in the form of a white powder, which is called the *Magistery of Coral, of Pearls, &c.*

PROCESS II.

The Acid of Vinegar combined with Copper. Verdegris. Crystals of Copper. This combination decomposed. Spirit of Verdegris.

INTO a large matrafs put Verdegris in powder. Pour on it distilled Vinegar to the depth of four fingers breadth. Set the matrafs in a moderate sand-heat, and leave the whole in digestion, shaking it from time to time. The Vinegar will acquire a very deep blue-green colour. When the liquor is sufficiently coloured, pour it off by inclination. Put some fresh Vinegar into the matrafs; digest as before; and decant the liquor again when it is sufficiently coloured. Proceed in this manner till the Vinegar will extract no more colour. There will remain in the matrafs a considerable quantity of undissolved matter. The Vinegar thus impregnated with Verdegris is called *Tincture of Copper*.

Mix these several Tinctures, and evaporate them with a gentle heat to a pellicle. Then set the liquor in a cool place: in the space of a few days a great many crystals of a most beautiful green colour will shoot therein, and stick to the sides of the vessel. Pour off the liquor from the crystals; evaporate it again to a pellicle, and set it by to crystallize. Continue these evaporations and crystallizations, till no more crystals will shoot in the liquor. These are called *Crystals of Copper*, and are used in painting. To this combination of the Acid of Vinegar with Copper the painters and dealers have given the title of *Distilled Verdegris*.

OBSERVATIONS.

VERDEGRIS is prepared at Montpellier. To make it they take very clean plates of Copper, which they lay, one over another, with husks of grapes

between, and after a certain time take them out. Their surfaces are then covered all over with a very beautiful green crust, which is *Verdegris*. This *Verdegris* is nothing but Copper corroded by the Acid of Tartar, analogous to the Acid of Vinegar, which abounds in the Wines of Languedoc, and especially in the rape, husks, and stones of grapes that have a very austere taste. *Verdegris* is a sort of rust of Copper; or Copper corroded and opened by the Acid of Wine; but not yet converted entirely into a Neutral Salt; for it is not soluble in water, nor does it crystallize. This arises from its not being united with a sufficient quantity of Acid. The design of the operation here described is to furnish the *Verdegris* with the quantity of Acid requisite to make it a true Metallic Salt, for which purpose distilled Vinegar is very fit.

Crystals of Copper may be obtained, without employing *Verdegris*, by making use of Copper itself dissolved by the Acid of Vinegar, according to the method practised with respect to Lead, as shall be shewn hereafter. But *Verdegris* is generally used, because it dissolves soonest; it being a Copper already half dissolved by an Acid correspondent to that of Vinegar.

Crystals of Copper are decomposed by the action of fire alone, without any additament; because the Acid of Vinegar adheres but loosely to Copper. In order to decompose this Salt, and extract its Acid, it must be put into a retort, and distilled in a reverberatory furnace with degrees of fire. An insipid phlegm rises first, which is the water retained by the Salt in crystallizing. This phlegm is succeeded by an acid liquor, which rises in the form of white vapours that fill the receiver. Towards the end of the distillation the fire must be violently urged, in order to raise the strongest and most fixed Acid. At last there remains in the retort a
black

black matter, which is nothing but Copper, that may be reduced by melting it in a crucible with one part of Salt-petre and two parts of Tartar. A similar Acid, but more oily, and in a much smaller quantity, may be obtained from Verdegris by distillation.

The Acid, which in this distillation comes over after the first phlegm, is an exceeding strong and concentrated Vinegar. It is known by the title of *Spirit of Verdegris*. Zwelfer, and after him M. le Fevre in his Chymistry, bestows extraordinary praises on this Spirit, pretending that it will produce the Salt of Coral, and others of the same kind, without losing any of its virtue, or ceasing to be acid; so as to remain still capable of performing other operations of the same nature. But Mr. Boerhaave and Mr. Lemerî positively deny the fact: and with good reason, having formed their judgments on their own experiments.

Yet I can hardly think both Zwelfer and le Fevre would have affirmed a thing of this nature, in such a positive and confident manner, if they had been convinced in their minds that it was false. We must suppose that those Chymists examined the matter with too little attention, and were misled by some fallacious appearance. Probably they may have compared this concentrated Vinegar with common distilled Vinegar; they may have put to their Coral an equal dose thereof; and, after saturation, they may have distilled off the superfluous liquor, which may have effervesced with fresh Coral and dissolved it. Surprised at this effect, they may have imagined that their Acid had lost none of its strength, and that it had the virtue of converting into Salt, any quantity of Coral, or such other matters, without any prejudice to its Acidity. A rash conclusion: which certainly they never would have made, if they had carried the experiment far enough; if they

they had dissolved a third or a fourth quantity of Coral in their Vinegar: for they would have been thereby convinced that the Spirit of Verdegris, like all other acid Spirits, deposits and leaves its Acid in absorbent matters; and that if the liquor, which they drew off by distillation from their first Salt of Coral, was still acid, and capable of dissolving fresh Coral, nothing could be inferred from thence but that Spirit of Verdegris is an exceedingly concentrated Vinegar, which, in the same quantity of liquor, contains much more Acid than the strongest distilled Vinegar prepared in the common way; that therefore a much smaller dose thereof is required to convert a given quantity of Coral into Salt; and that the liquor, which they distilled from their first Salt, still retained some of its virtue, only because it was replete with much more Acid than could be neutralized by the Coral. But a love of the marvellous so prepossesses the mind of man, that it often hinders him from perceiving the most obvious facts. This is the fault of all the ancient Chymists in general; and I believe the only reason why we find their books stuffed with so many unsucceeding experiments was, that their heated imaginations frequently represented things to them otherwise than they really were.

P R O C E S S III.

The Acid of Vinegar combined with Lead. Ceruse. Salt or Sugar of Lead. This combination decomposed.

IN T O the glass head of a cucurbite, put thin plates of Lead, and secure them so that they may not fall out when the head is put upon the cucurbite. Fit on this head to a wide-mouthed cucurbite.

curbite containing some Vinegar. Set it in a sand-bath; lute on a receiver, and distill with a gentle heat for ten or twelve hours. Then take off the head: in it you will find the leaden plates covered, and, in a manner, cruſted over, with a white matter. This being bruſhed off with a hare's foot is what we call *Ceruse*. The leaden plates thus cleaned may be employed again for the ſame purpoſe, till they be wholly converted into *Ceruse* by repeated diſtillations. During the operation, there will come into the receiver a liquor ſomewhat turbid and whitish. This is a diſtilled Vinegar in which ſome Lead is diſſolved.

Reduce a quantity of *Ceruse* into powder; put it into a matraſs: pour on it twelve or fifteen times as much diſtilled Vinegar; ſet the matraſs in a ſand-bath; leave the matter in digeſtion for a day, ſhaking it from time to time: then decant your liquor, and keep it apart. Pour freſh Vinegar on what is left in the matraſs, and digeſt as before. Proceed thus till you have diſſolved one half, or two-thirds, of the *Ceruse*.

Evaporate to a pellicle the liquors you poured off from the *Ceruse*, and ſet them in a cool place. Greyiſh cryſtals will ſhoot therein. Decant the liquor from the cryſtals; evaporate it again to a pellicle, and ſet it by to cryſtallize. Proceed thus evaporating and cryſtallizing as long as any Cryſtals will ſhoot. Diſſolve your cryſtals in diſtilled Vinegar, and evaporate the ſolution, which will then ſhoot into whiter and purer cryſtals. This is the *Salt* or *Sugar of Lead*.

OBSERVATIONS.

LEAD is eaſily diſſolved by the Acid of Vinegar. If it be barely expoſed to the vapour of that Acid, its ſurface is corroded, and converted into a kind of calx or white ruſt, much uſed in painting, and known by

by the name of *Ceruse* or *White Lead*. But this preparation of Lead is not combined with a sufficient quantity of Acid to convert it into a Salt: it is no more than Lead divided and opened by the Acid of Vinegar; a matter which is to Lead what *Verdegris* is to Copper. And therefore if you desire to combine *Ceruse* with the quantity of Acid necessary to convert it into a Neutral Salt, you must treat it in the same manner as we did *Verdegris*, in order to procure Crystals of Copper; that is, you must dissolve it in distilled Vinegar, as the process directs.

The Salt of Lead is not very white when it first shoots; and for this reason it is dissolved again in distilled Vinegar, and crystallized a second time. If Salt of Lead be repeatedly dissolved in distilled Vinegar, and the liquor evaporated, it will grow thick; but cannot be desiccated without great difficulty. If the same operation be oftener repeated, this quality will be thereby more and more increased; till at last it will remain on the fire like an Oil, or melted Wax: it coagulates as it cools, and then looks, at first sight, like a metallic mass, somewhat resembling Silver. This matter runs with a very gentle heat, almost as easily as Wax.

The Salt of Lead hath a saccharine taste, which hath procured it the name also of Sugar of Lead. For this reason when Wine begins to turn sour, the ready way to cure it of that disagreeable taste is, to substitute a sweet one which is not disagreeable to the taste, by mixing therewith *Ceruse*, *Litharge*, or some such preparation of Lead: for the Acid of the Wine dissolves the Lead, and therewith forms a Sugar of Lead, which remains mixed with the Wine, and hath a taste which, joined with that of the Wine, is not unpleasant. But, as Lead is one of the most dangerous poisons we know, this method ought never to be practised; and whoever employs

such a pernicious drug deserves to be most severely punished. Yet something very like this happens every day, and must needs have very bad consequences; while there is nobody to blame, and those to whom the thing may prove fatal can have no mistrust of it.

All the retailers of Wine have a custom of filling their bottles on a counter covered with Lead, having a hole in the middle, into which a Leaden pipe is foldered. The Wine which they spill on the counter, in filling the bottles, runs through this pipe into a Leaden vessel below. In that it usually stands the whole day, or perhaps several days; after which it is taken out of the Leaden vessel, and mixed with other Wine, or put into the bottle of some petty customer. But, alas for the man to whose lot such Wine falls! He must feel the most fatal effects from it; and the danger to which he is exposed is so much the greater, the longer the Wine hath stood in the Leaden Vessel, and thereby acquired more of a noxious quality. We daily see cruel distempers among the common people, occasioned by such causes, which are not sufficiently attended to.

Wine that is not kept in close vessels is apt to turn sour very soon, especially in the summer; and the retailers of Wine have observed that their drippings, thus collected in vessels of Lead, are not liable to this inconvenience. This is what hath established among them the practice I am speaking against. As they see only the good effects thereof, and know nothing of its ill consequences, we cannot be angry with them. It is natural to think, that, as Lead hath the property of keeping Wine cool, it may by that means prevent its growing sour for some time; and persons who are not versed in Chymistry can hardly suspect that Wine is preserved from being pricked, only by being converted into a kind of poison.

poison. Yet this is the very case: for Lead doth not hinder the Wine from growing sour; but, uniting with its Acid, as soon as it appears, and forming therewith a Sugar of Lead, changes the taste thereof, as hath been said, and hinders the Acid from affecting the palate.

Hence it appears how much it were to be wished that the use of those counters covered with Lead were abolished entirely. I am informed, by a Chymist zealous for the public good *, that he represented this matter to the Magistrates several years ago. It is not to be doubted, that, when the dealers in Wine know the ill consequences attending this practice, they will with pleasure sacrifice the small benefit they receive from it to the public safety.

It is easy to prove whether or no a suspected Wine contains Lead. You need only pour into it a little Oil of Tartar *per deliquium*; or, if you have not that at hand, a lye of the ashes of green wood. If there be any Lead dissolved in it, the liquor will immediately grow turbid, and the Lead will precipitate in the form of a white powder; because the Sugar of Lead it contains, being a Neutral Salt whose basis is a metal, is decomposed by the Fixed Alkali, which separates that metal from the Acid. Lead thus separated from the Acid of Vinegar by an Alkali is called *Magistery of Lead*.

* Mr. Rouelle, whom I have had occasion to mention several times in this work with the honour which he deserves, and with whom I went through a Course of Chymistry when I was a student in Medicine. It must be observed, to the praise of this ingenious Artist, that he is the first Frenchman that ever gave courses of Chymistry. In these he explains the operations according to the true and sound Theory of the Science drawn from the writings of Beccher, Stahl, Juncker, Boyle, Boerhaave, Lavoisier, and many other excellent Chymists, whom it would be tedious to mention here, as well as from the Memoirs of the most celebrated Academies, particularly those of the Academy of Sciences at Paris.

Ceruse, or White Lead, is also a very dangerous poison. It is a pigment very much used, being the only White that can be applied with Oil. This White is the most common, or perhaps the only cause of those dreadful colicks, with which painters, and all that work in colours, are frequently afflicted. This induced me to examine all the substances capable of affording a White, in order to find one, if possible, which might be substituted for White Lead: but, after a vast number of experiments, I had the mortification to be convinced that all Whites, even the brightest and most beautiful, which are not metallic, produced nothing, when ground with Oil, but greys, or dirty yellows. There is still something to be hoped for in Whites obtainable from certain metallic substances: but, as every one of those matters may be suspected of some noxious quality, long experience alone will remove our just apprehensions of danger from every thing afforded by such substances.

To return to the Salt of Lead; it may be decomposed by distillation without additament. In order to perform this, you must put the Salt of Lead into a glass or stone retort, leaving a full third thereof empty, and distill in a reverberating furnace with degrees of fire. A spirit rises, which fills the receiver with clouds. When nothing more will come over with a fire that makes the retort red-hot, let the vessels cool, and then unlute them. You will find in the receiver an austere liquor, which is inflammable; or, at least, an inflammable Spirit may be obtained from it, if about one half thereof be drawn off by distillation in a glass alembic. The retort in which the Salt of Lead was decomposed contains, at the end of the operation, a blackish matter: this is Lead, which will resume its metallic form on being melted in a crucible;

cible; because the Acid by which it was dissolved, and from which it hath been separated, being of a very oily nature, hath left in it a sufficient quantity of phlogiston.

What is most remarkable in this decomposition of Salt of Lead is the inflammable Spirit which it yields, though the Vinegar which entered into the composition of the Salt seemed to contain none at all.

C H A P. - VII.

OF THE PUTRID FERMENTATION OF VEGETABLE SUBSTANCES.

P R O C E S S I.

The Putrefaction of Vegetables.

FILL a hoghead with green plants, and tread them down a little; or, if the vegetables be dry and hard substances, divide them into minute parts, and steep them a little in water to moisten them: then leave them, or the green plants, in the vessel, uncovered and exposed to the open air. By degrees a heat will arise, in the center of the vessel, which will continue increasing daily, at last grow very strong, and be communicated to the whole mass. As long as the heat is moderate, the plants will retain their natural smell and taste. As the heat increases, both these will gradually alter, and at last become very disagreeable, much like those of putrid animal substances. The plants will then be tender as if they had been boiled; or even be reduced to a

kind of pap, more or less liquid according to the quantity of moisture they contained before.

OBSERVATIONS.

ALMOST all vegetable matters are susceptible of putrefaction; but some of them rot sooner, and others more slowly. As putrefaction is only a species of fermentation, the effect whereof is to change entirely the state of the Acid, by combining it with a portion of the earth and Oil of the mixt, which are so attenuated that from this union there results a new saline substance in which no Acid is discernible; which on the contrary hath the properties of an Alkali, but rendered volatile; it is plain, that the nearer the Acid of a plant set to putrefy is to this state, the sooner will the putrefaction of that plant be completed. Accordingly all plants that contain a Volatile Alkali ready formed, or from which it can be obtained by distillation, are the most disposed to putrefaction.

Those plants, in which the Acid is very manifest and sensible; are less apt to putrefy; because all their Acid must undergo the change above specified. But vegetable matters, whose Acid is entangled and clogged by several of their other principles, must be still longer elaborated, before they can be reduced to the condition into which complete putrefaction brings all vegetables. The earthy and oily parts, in which the Acids of these substances are sheathed, must be attenuated and divided by a previous fermentation, which, from those parts subtilized and united with the Acid, forms an Ardent Spirit, wherein the Acid is more perceptible than in the almost insipid, or saccharine, juices out of which it is produced. The Acid contained in the Ardent Spirit must be still further disengaged, before it can enter into the combination of a Volatile Alkali:

Alkali: consequently the Ardent Spirit must undergo a sort of decomposition; its Acid must be rendered more sensible, and be brought to the same condition as the Acid of plants in which it manifests all its properties.

Hence it appears that the spirituous and acetous fermentations are only preparatives, which nature makes use of, for bringing certain vegetable matters to putrefaction. These fermentations therefore must be considered as advances towards that putrefaction, in which they terminate, or rather, as the first stages of putrefaction itself. This is the opinion of Mr. Stahl, who hath treated this subject with great sagacity, and thrown much light upon it.

Mr. Boerhaave is not altogether of the same mind. He considers putrefaction as something foreign to fermentation; as an operation independent of it, and very different from it. He gives the title of fermentation to that intestine and spontaneous motion only which produces an Ardent Spirit, and changes it into an Acid. He founds his opinion on this, that the circumstances attending putrefaction are different from those which accompany spirituous and acetous fermentation; that the product of putrefaction is very different from the products of these fermentations; and lastly, that all vegetable and animal substances are susceptible of putrefaction, whereas only some kinds of them are capable of fermentation, properly so-called.

Mr. Boerhaave is so far right, that we ought not to confound together operations which differ in several respects, and result in different productions; but Mr. Stahl's opinion must nevertheless be looked on as highly probable, or rather absolutely true. For it doth not necessarily follow, from the difference between the circumstances and productions of fermentative motions, that the operations have no relation to, or connection with, each other. They
may

may nevertheless be considered as different steps of one and the same operation: and if all vegetable and animal matters are not susceptible of the three degrees of fermentation, we can only infer from thence that there are mixts, in which the whole work of fermentation is yet to do; and that there are others whose principles are so disposed that they are in the same condition as if they had already undergone the first, or even the second, degree of fermentation; and consequently such mixts are susceptible only of the second, or perhaps of the third, degree of fermentation.

Mr. Stahl therefore says very judiciously, that, far from denying putrefaction to be a fermentation, we ought on the contrary to consider all fermentation as no other than putrefaction. Matters susceptible of the spirituous and acetous fermentation do but pass through these previous alterations in their way to complete putrefaction. On this principle Wine and Vinegar are only liquors that had begun to putrefy, but were stopt at the first or second stage of their putrefaction. This is so true, that, if a fermenting liquor be left to itself in the open air, and in a due degree of heat, it will proceed directly, without any stop, to perfect putrefaction.

The acetous fermentation is attended with more heat than the spirituous, and the putrid with still more than the acetous. The heat of putrefying plants is sometimes so considerable, that, when they are not too moist, and are stacked up in great heaps, they take fire and burn violently. Of this there are frequent instances in hay-ricks.

PROCESS II.

Putrefied Vegetable Substances analyzed.

PUT the putrefied plants you mean to analyze into a glass cucurbite, and set it in a sand-bath. Fit to it a head; lute on a receiver: distill with a gentle fire, and a limpid fetid liquor will come over. Continue the distillation till the matter contained in the retort be almost dry.

Then unlute your vessels, and keep the liquor you find in the receiver by itself. Put the matter remaining in the cucurbite into a retort, and distill with a graduated heat. There will rise white vapours; a pretty considerable quantity of liquor nearly like that of the former distillation; a Volatile Salt in a concrete form; and a black Oil, which towards the end will be very thick. In the retort there will remain a black charred matter, which being burnt in the open air will fall into ashes, from which no Fixed Alkali can be extracted.

By means of a funnel separate your Oil from the aqueous liquor. Distill this liquor with a gentle heat. You will by this means obtain a Volatile Salt like that of animals; of which you may also get some, by the same means, from the liquor which came over in the first distillation.

OBSERVATIONS.

THIS analysis shews the changes which putrefaction produces in vegetable matters. Scarce any of their principles are now to be discerned. They now yield no aromatic liquor; no Essential Oil; no Acid; and consequently no Essential Salt, Ardent Spirit, or Fixed Alkali: in a word, whatever their natures were before putrefaction, they are all alike when they have once undergone this fermentative motion
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in its full extent. Nothing can then be obtained from them but Phlegm, a Volatile Alkali, a fetid Oil, and an insipid Earth.

Almost all these changes are owing to the transmutation of the Acid, which is depraved by putrefaction, and combined with a portion of the Oil and subtilized Earth of the mixt; so that the result of their union is a Volatile Alkali. Now, as the Fixed Alkali, found in the ashes of unputrefied plants, is only the most fixed part of their earth and of their Acid, closely united together by the igneous motion, it is not surprising that, when all the Acid, with a part of the earth, is subtilized and volatilized by putrefaction, no Fixed Alkali can be found in the ashes of putrefied Vegetables. The alteration which the Acid suffers by the putrefactive motion is, in my opinion, the greatest it can undergo, without being entirely destroyed and decomposed, so as to be no longer a Salt.

We have seen it, in the Mineral kingdom, in its greatest purity and strength. Its combination with Oil, and the other alterations it undergoes, in the Vegetable kingdom, have shewn it weakened and disguised. The changes it suffers by the spirituous and acetous fermentation, have exhibited it in other forms. And, lastly, putrefaction disfigures it completely, and, in some sort, changes its very nature, so that it cannot be distinguished. In the animal kingdom we find it nearly in the same condition: for though the Vegetable substances on which animals feed, do not undergo direct putrefaction, in its full extent, before they are converted into animal juices, yet they suffer most of the alterations produced by putrefaction; so that when they have acquired the qualities necessary to their becoming an actual nutritious animal juice, they are within one step of complete putrefaction. For this reason all animal substances are very apt to putrefy, and are
unsusceptible

unsusceptible of the first degrees of fermentation. But this discussion belongs to the animal kingdom, of which we are now going to treat in the third part of these Elements; the theory of putrefaction serving to introduce it, and naturally leading us to it.

PART III.

Of Operations on Animal Substances.

CHAP. I.

OF MILK.

PROCESS I.

Milk separated into Butter, Curd, and Whey: instanced in Cow's Milk.

PUT new Cow's milk into a flat earthen pan, and set it in a temperate heat. In ten or twelve hours time there will gather on its surface a thick matter, of a somewhat yellowish white: this is called *Cream*. Gently skim off this Cream with a spoon, letting the milk you take up with it run off. Put all this Cream into another vessel, and keep it. The milk thus skimmed will not be quite so thick as before: nor will it be of such a dead white, but have a little blueish cast. If all the Cream be not separated from it, more will gather on its surface after some time, which must be taken off as the former. In two or three days the skimmed milk will

will coagulate into a soft mass, called *Curd*, and then it tastes and smells sour.

Cut this *Curd* across in several places. It will immediately discharge a large quantity of *Serum*. Put the whole into a clean linen cloth; hang it up; and underneath it set a vessel to receive the *Serum* as it drops. When the aqueous part hath done dripping, there will remain in the filter a white substance somewhat harder than the curdled milk. This substance is called *Cheese*, and the *Serum* separated from it is known by the name of *Whey*.

OBSERVATIONS.

THE milk of animals, that feed only on vegetables, is of all animal matters the least removed from the vegetable nature. The truth of this will be demonstrated by the experiments we shall produce by and by, for the further analysis of milk. For this reason we judged, with Mr. Boerhaave, that it was proper to begin the analysis of animals by examining this liquor.

Most Chymists justly consider Milk as of the same nature with Chyle. Indeed there is great reason to think, that, except some small differences to be afterwards taken notice of, these two matters are nearly the same. They are both of a dead white colour, like that of an emulsion; which proves that, like emulsions, they consist of an oily matter, divided, diffused, and suspended, but not perfectly dissolved, in an aqueous liquor.

It is not surprising that these liquors should resemble emulsions; for they are produced in the same manner, and may very justly be called *Animal Emulsions*. For how are vegetable substances converted into Chyle and Milk in an animal body? They are bruised, divided, and triturated by mastication and digestion, as perfectly, at least, as the matters

matters pounded in a mortar to make an emulsion : and must thereby undergo the same changes as those matters ; that is, their oily parts, being attenuated by those motions, must be mixed with and lodged between the aqueous parts, but not dissolved therein ; because they do not, in the bodies of animals, meet with saline matters, sufficiently disentangled and active, to unite intimately with them, and by that means render them soluble in water.

Nevertheless Chyle and Milk, though produced in the same manner as emulsions, and very much resembling them, differ greatly from them in some respects ; owing chiefly to the time they remain in the bodies of animals, their being heated while there, the elaborations they undergo therein, and the animal juices commixed with them.

New Milk hath a mild agreeable taste, without any saline pungency ; nor hath any Chymical trial discovered in it either an Acid or an Alkali. Yet it is certain that the juices of plants, out of which milk is formed, contain many saline matters, and especially Acids : accordingly Milk also contains the same ; but the Acids are so sheathed and combined, that they are not perceptible. The case is the same with all the other liquors intended to constitute part of an animal body : there is no perceptible Acid in any of them.

Hence it may be inferred that one of the principal changes which vegetables undergo, in order to their being converted into an animal substance, consists in this, that their Acids are combined, entangled, and sheathed in such a manner that they become imperceptible, and exert none of their properties.

Milk left to itself, without the help of distillation, or any additament whatever, undergoes a sort of decomposition. It runs into a kind of spontaneous analysis : which doth not indeed reduce it to its first principles, yet separates it into three

distinct substances, as the process shews; namely, into Cream, or the buttery fat part, into Curd or Cheese, and into Serum or Whey: which shews that those three substances of which Milk consists, are only mixed and blended together, but not intimately united.

The first parts, being the lightest, rise gradually to the surface of the liquor as they separate from the rest: and this forms the Cream.

Cream, as skimmed from the surface of Milk, is not however the pure buttery or fat part: it is still mixed with many particles of Cheese and Whey, which must be separated in order to reduce it into Butter. The most simple, and at the same time the best method of effecting this, is daily practised by the country people. It consists in beating or churning the Cream, in a vessel contrived for that purpose, with the flat side of a circular piece of wood, in the center of which a staff is fixed. One would think that the motion impressed on the Cream by this instrument, should rather serve to blend more intimately the particles of Butter, Cheese, and Whey, of which it consists, than to separate them from each other; as this motion seems perfectly adapted to divide and attenuate those particles. But, if we consider what passes on this occasion, we shall soon perceive that the motion by which Butter is churned is nothing like triture: for churning is no other, properly speaking, than a continually repeated compression, the effect whereof is to squeeze out from amongst the buttery particles those of Cheese and Whey mixed therewith; by which means the particles of Butter are brought into contact with each other, unite, and adhere together.

Milk, whether skimmed or no, grows sour of itself, and curdles in a few days. When it is newly curdled, the Cheese and Whey seem to be united,
and

and to make but one mass : but these two matters separate spontaneously from each other, with the greatest ease, and in a very short time.

The Acidity, which Milk naturally contracts in the space of a few days, must be considered as the effect of a fermenting motion, which discovers in that liquor an Acid that was not perceptible before. This, properly speaking, is an acetous fermentation, which Milk passes through in its way to putrefaction ; and it soon follows, especially if the Milk be exposed to a hot air.

If, instead of leaving Milk to grow sour and curdle of itself, an Acid be mixed therewith, while it is yet sweet and newly milked, it immediately coagulates ; which gives reason to think that its curdling naturally is the effect of the Acid, which discovers itself therein as it grows stale.

The coagulation of Milk may also be considerably accelerated, by setting it in a sand-bath gently heated ; or by mixing therewith a little of what, in the language of the Dairy, is called *Runnet* ; which is nothing but some curdled and half-digested Milk taken from the stomach of a Calf ; or both these methods may be employed at once, which will produce the effect still more expeditiously.

It is not difficult to find out the cause of these effects. The *Runnet*, which is Milk already curdled and grown sour, is an actual ferment to sweet Milk, disposing it to turn sour much more readily : for though Milk, when thus hastily curdled by the *Runnet*, hath not a manifestly Acid taste, yet it is certain that this Acid begins to exert itself. The proof thereof is, that, being exposed to the same degree of heat with Milk equally new, that is not mixed with this ferment, it turns sour much sooner. As to the effect of heat in coagulating Milk, there is nothing extraordinary in it : we know how much it promotes and accelerates all fermentative motion.

The whole of this perfectly agrees with what we said before concerning fermentation.

Fixed Alkalies also coagulate Milk; but at the same time they separate the Whey from the Cheese, which floats on the liquor in clots. They give the Milk a russet colour inclining to red; which may arise from their attacking the fat part.

The separation of Milk into Butter, Cheese, and Whey, is a kind of imperfect analysis thereof, or rather the beginning of one. In order to render it complete, we must examine each of these substances separately, and find the principles of which they consist. This we shall endeavour to do in the following process.

PROCESS II.

Butter analyzed by Distillation.

INTO a glass retort put the quantity of fresh Butter you intend to distill. Set the retort in a reverberatory; apply a receiver; and let your fire be very gentle at first. The Butter will melt, and there will come over some drops of clear water, which will have the peculiar smell of fresh Butter, and shew some tokens of Acidity. If the fire be increased a little, the Butter will seem to boil: a froth will gather on its surface, and the phlegm, still continuing to run, will gradually come to smell just like Butter clarified in order to be preserved. Its Acidity will be stronger and more manifest than that of the first drops that came over.

Soon after this, by increasing the fire a little more, there will rise an Oil, having nearly the same degree of fluidity as fat Oils; but it will grow thicker as the distillation advances, and at last will fix in the receiver when it cools. It will be accom-

panied with some drops of liquor, the Acidity whereof will always increase, while its quantity decreases, as the distillation advances.

While this thick Oil is distilling, the Butter contained in the retort, which at first seemed to boil, will be calm and smooth, without the least appearance of ebullition; though the heat be then much greater than when it boiled. Continue the distillation, constantly increasing the fire by degrees as you find it necessary for the elevation of the thick Oil. This Oil, or rather this kind of Butter, will be at last of a russet colour. There will rise along with it some white vapours exceeding sharp and pungent.

When you observe that nothing more comes over, though the retort be quite red-hot, let the vessels cool, and unlute them. You will find in the receiver an aqueous acid liquor, a fluid Oil, and a kind of fixed brown Butter. Break the retort, and you will find therein a charred matter; the surface of which, where it touched the glass, will be of a shining black, and have a fine polish.

OBSERVATIONS.

THE analysis of Butter proves that this substance, which is an oily matter in a concrete form, owes its consistence to the Acid only, with which the oily part is combined: that is, it follows the general rule frequently mentioned above in treating of other oily compounds; the consistence whereof we shewed to be so much the firmer, the more Acid they contain. The first portions of Oil that come over in the distillation of Butter are fluid, because a pretty considerable quantity of Acid rose before them, which being mixed with the phlegm gives it the Acidity we took notice of.

This Oil, being freed from its Acid, and by that means rendered fluid, rises first; because it is by

the same means rendered lighter. The kind of Butter that comes over afterwards, though it be fixed, is nevertheless far from having the same consistence as it had before distillation; because it loses much of its Acid in the operation. This Acid is what rises in the form of white vapours. These vapours are, at least, as pungent and irritating as the Sulphureous Acid, or Volatile Alkalis: but their smell is different: it hath the resemblance, or rather is the same, with that which rises from Butter, when it is burnt and browned in an open vessel. But, when concentrated and collected in close vessels, as in the distillation of Butter, they are vastly stronger: they irritate the throat so as to inflame it; they are exceeding sharp and pungent to the smell, and are so hurtful to the eyes that they quickly inflame them, as in an ophthalmy, and make them shed abundance of tears. The great volatility of this Acid is entirely owing to a portion of the phlogiston of the Butter with which it is still combined.

It may be asked why Butter, or the oily part of Milk, which hath the consistence of a Fixed Oil, is more replete with an Acid than the Oils of the vegetables whereof the Milk was formed; as these Oils are almost all fluid, which indicates their containing less Acid before than after they were digested in the body of an animal. This must appear the more extraordinary, because the Acid contained in the liquors of animals is sheathed and imperceptible, and consequently incapable of combining with the Oils of Vegetables so as to give them this consistence.

I think it will be easy to give a satisfactory answer to this question, if it be considered that the Oils, which exist in the vegetable juices whereof the Milk is formed, are far from being combined with the whole Acid of those vegetables; because there is hardly a plant that doth not yield a great deal of
Acid,

Acid, even without the help of fire. Now, there is reason to think, that one of the principal effects of digestion is, to combine and unite this Acid, with the oily parts of vegetables, more intimately than it was before.

The further we advance in the analysis of animals, the more we shall be convinced, that, in the different elaborations, which vegetable substances undergo in order to their being changed into the nutritious juices of animals, nature employs all her powers to expell, destroy, or at least weaken and blunt, the Acids, so as to render them absolutely imperceptible. One of the best means by which she can effect this, is the combining and uniting them intimately with the oily parts: and this operation she probably begins in digestion. She gets rid of most part of the Acids contained in the aliments, by thus uniting them with the Oils contained in those aliments. Hence arises the consistence of Butter, which is the fat part of Milk, that is, of a liquor half-changed into an animal juice.

This explication furnishes us also with the reason why Acids agree so ill with people of weak and delicate constitutions. The motion and heat in their bodies is not sufficient to effect a due combination of the Acids with the Oils. Hence it comes to pass, that, during and after digestion, they find in their bowels the bad effects of those Acids, in the disorder commonly called the *Heart-burn*. Hence also it is, that such people receive great benefit from the use of Absorbents, which uniting with the Acids, neutralize them, and relieve Nature when she has not strength enough herself to get the better of them.

To return to our analysis of Butter: we took notice in the process that Butter seems to boil with a very moderate heat at the beginning of the distil-

lation, and that in the course of the operation the ebullition ceases entirely, though the heat be then greatly encreased ; which is contrary to the general rule. The reason is, that Butter, though a seemingly homogeneous mass, contains nevertheless some particles of Cheese and Whey. The particles of Whey, being much the lightest, endeavour, on the first application of heat, to extricate themselves from amongst the particles of Butter, and to rise in distillation. Thus they form the drops of acidulated phlegm which come over at first, and, in struggling to get free, lift up the buttery parts, or actually boil, which occasions the ebullition observable at the beginning of the process. When they are once separated, the melted butter remains calm and smooth, without boiling. If you want to make it boil you must apply a much greater degree of heat ; which you cannot do in close vessels, without spoiling the whole operation ; because the degree of heat necessary for that purpose would force up the Butter in substance, which would rush over into the receiver, without any decomposition. Indeed if the vessels were luted they would be in danger of bursting.

As to the caseous parts, which are mixed with fresh butter, they also separate at the beginning of the distillation, when the Butter is melted, and gather on its surface in a scum. These particles of Cheese and Whey, which are heterogeneous to Butter, help to make it spoil the sooner. And for this reason those who want to keep Butter a long time, without the use of Salt, melt it, and thereby evaporate the aqueous parts. The lightest portion of the particles of Cheese rises to the surface, and is skimmed off ; the rest remains at the bottom of the vessel, from which the Butter is easily separated, by decanting it while it is yet fluid.

Butter

Butter may also be distilled, by incorporating it with some additament which will yield no principle itself, nor retain any of those of the Butter. I have distilled it in this manner with the additament of fine sand: the operation succeeds very well, is sooner finished, and more easily conducted: but I chose to describe here the manner of doing it without additament; because the several changes, which the Butter undergoes in the retort during the operation, may be better observed.

If you desire to convert the Butter wholly into Oil, you must take the fixed matter you find in the receiver, and distill it once more, or oftener, according to the degree of fluidity you want to give it. The case is the same with this matter as with all other thick Oils, which, the oftener they are distilled, grow always the more fluid, because in every distillation they are separated from part of the Acid, to which alone they owe their consistence.

P R O C E S S III.

The Curd of Milk analyzed by Distillation.

INTO a glass retort put some new Curd, having first drained it thoroughly of all its Whey, and even squeezed it in a linen cloth to express all its moisture. Distill it as you did Butter. There will come over at first an acidulated phlegm, smelling like Cheese or Whey. As the distillation advances, the Acidity of this phlegm will increase.

When it begins to run but very slowly raise your fire. There will come over a yellow Oil, somewhat empyreumatic. Continue the distillation, still increasing the fire by degrees, as occasion requires. The Oil and Acid Phlegm will continue to rise; the Phlegm growing gradually more acid, and the Oil

deeper coloured, and more empyreumatic. At last, when the retort is almost red-hot, there comes off a second black Oil, of the consistence of Turpentine, very empyreumatic, and so heavy as to sink in water. In the retort will be left a considerable quantity of charred matter.

OBSERVATIONS.

CHEESE-CURD barely drained, till no more Whey will drip from it, is not entirely freed thereof; and for this reason we directed it to be pressed in a linen cloth, before it be put into the retort to be distilled. Without this precaution the remaining Whey would rise in a considerable quantity on the first application of heat; and instead of analyzing the Curd only, we should at the same time analyze the Whey also. This is to be understood of green Curd and new-made Cheese; for, if it be suffered to grow old, it will at length dry of itself: but then we should not obtain from it the same principles by distillation, as it corrupts and begins to grow putrid after some time, especially if it be not mixed with some seasoning to preserve it.

The first Phlegm that rises in this distillation, as in that of Butter, is a portion of the Whey that was left in the Cheese, notwithstanding its being well pressed. This Phlegm grows gradually more acid, being the vehicle of the Acids of the Cheese, which are forced up along with it by the fire.

The Acid obtained from this matter is less in quantity, and weaker, than that of Butter: and accordingly the Oil distilled from Cheese is not fixed like that of Butter. Yet it is remarkable that the last empyreumatic Oil, which is as thick as Turpentine, is heavier than water: a property which it probably derives from the quantity of Acid it retains.

The

The quantity of charred matter, which remains in the retort after the distillation of Cheese, is much greater than that left by Butter; which proves that the former contains a much greater quantity of earth. These coals are exceeding difficult to burn and reduce to ashes. I have kept them red-hot, in the open air, and in a very strong fire, above six hours, continually stirring them, in order to bring the under parts to the surface, that they might be burnt, yet I could not consume them entirely. They even deflagrated afterwards with Nitre, as if they had not been burnt at all; and yet, during the whole time of their calcination, there appeared constantly a small flame, like that of charcoal, on the surface of the matter.

P R O C E S S IV.

Whey analyzed.

E V A P O R A T E two or three quarts of Whey almost to dryness in a *balneum mariæ*; and distill the extract, or residuum, in a retort set in a reverberating furnace, with degrees of fire, according to the general rule. At first some Phlegm will come over; then a lemon-coloured acid Spirit; and afterwards a pretty thick Oil. There will remain in the retort a charred matter, which being exposed to the air, grows moist. Lixivate it with rain-water, and evaporate the lixivium: it will yield you crystals of Sea-salt. Dry the charred matter, and burn it in the open air with a strong fire till it be reduced into ashes. A lixivium of these ashes will shew some tokens of a Fixed Alkali.

O B S E R-

OBSERVATIONS.

MILK, as was said before, separates naturally and spontaneously into three sorts of substances, the analyses whereof being put together, make a complete analysis of this animal liquor. I know no Author that hath delivered the analyses of Butter and Cheese; so that the processes here given for analyzing these two substances are taken from the experiments I thought proper to make, in order to obtain the necessary lights in this matter. As for the analysis of Whey, it is taken from one of Mr. Geoffroy's Memoirs, containing experiments on several animal substances, which was published in 1732. It is there so particularly and so well described, that it was needless for me to attempt it anew.

It will appear, on examining the three analyses of the substances whereof Milk consists, that none of them yields a Volatile Alkali: which I think very worthy of notice; as it is, I believe, the only animal matter from which such a Salt cannot be obtained. It is true, the Milk of animals that feed on vegetables may be considered as an intermediate liquor between vegetable and animal substances; as an imperfect animal juice, which still retains much of the vegetable nature: and we actually find that Milk almost always hath, at least in part, the properties of those plants with which the animals that yield it are fed. Yet, as it cannot be formed in the body of the animal, without mixing with several of its juices that are entirely perfected, and become purely animal, it must appear strange that the analysis thereof should not afford the least vestige of that principle, which all other animal matters yield in the greatest plenty.

I imagine the reason of this may be found in the use to which Milk is destined. It is intended
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for the nourishment of animals of the same species with those in whose bodies it is produced. Consequently it ought as much as possible to resemble the juices of the food which is proper for those animals. Now, as animals that live only on vegetables could not be properly nourished by animal matters, for which nature itself hath even given them an aversion, it is not surprising that the Milk of such animals should be free from any mixture of such things as are unsuitable to the young ones whom it is designed to nourish. There is reason therefore to think that nature hath disposed the organs, in which the secretion of Milk is performed, so as to separate it entirely from all the animal juices first mixed with it; and this I take to be the principal difference between Milk and Chyle; the latter being necessarily blended with the saliva, the gastric and pancreatic juices, the bile and lymph, of the animals in which it is formed. Hence it may be concluded, that, if a quantity of Chyle could be collected sufficient to enable us to analyze it, the analysis thereof would differ from that of Milk, in this chiefly, that it would yield a great deal of Volatile Alkali, of which Milk, as hath been said, yields none at all.

The same thing probably takes place in carnivorous animals. It is certain that those animals chuse to eat the flesh of such others only as feed upon vegetables, and that nothing but extreme hunger, and the absolute want of more agreeable food, will force them to eat the flesh of other carnivorous animals. Wolves, which greedily devour Sheep, Goats, &c. seldom eat Foxes, Cats, Polecats, &c. though these animals are not strong enough to resist them. Foxes, Cats, and Birds of prey, that make such terrible havock among wild fowl, and other sorts of game, do not devour one another. This being laid down, there is reason to think that
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the Milk of carnivorous animals is something of the nature of the flesh of those animals that feed on vegetables, and which they chuse to eat, and not of the nature of their own flesh; as the Milk of animals, that feed on vegetables is analogous to the juice of vegetables, and when analyzed yields no Volatile Alkali, though every other part of their body does.

But whatever be the nature of Milk, and of whatever ingredients it be formed, it always contains the three several substances above mentioned; namely, the Fat, or Buttery part, properly so called, the Cheesy, and the Serous part, the last of which we are now examining. It is, properly speaking, the Phlegm of the Milk, and consists almost entirely of water. For this reason it is proper to lessen the quantity thereof considerably by evaporation, so that its other principles, being concentrated and brought nearer together, may become much more sensible. There is no danger of losing any essential part of the Whey in the evaporation, if it be performed in the *balneum mariæ*, with such a gentle heat as may carry off the aqueous parts only: this greatly shortens the analysis, which will prove exceeding long and tedious, if all the water be distilled off in close vessels.

As Whey is chiefly the aqueous part of Milk, as said above, it must contain all the principles thereof that are soluble in water; that is, its saline and saponaceous parts. And accordingly the analysis thereof shews that it contains an Oil, rendered perfectly saponaceous by an Acid; that is, made perfectly miscible with water. This quality of the Oil contained in Whey appears from the perfect transparency of that liquor, which we know is the mark of a complete dissolution. In the distillation of Whey, the saponaceous matter contained therein is decomposed; the saline part rises first, as being the lightest; this

this is the Acid taken notice of in the process; after which the Oil, now separated from the principle which rendered it miscible with water, comes over in its natural form, and doth not afterwards mix with the aqueous part.

Besides the saponaceous matter, Whey contains also another saline substance; namely, Sea-salt; this is obtained by lixiviating the *caput mortuum* left in the retort, which, because of its fixedness, cannot rise with the other principles in distillation. To this Salt it is owing that what remains in the retort after distillation grows moist in the air; for we know that Sea-salt thoroughly dried hath this property.

The fixed Alkaline Salt obtained from the *caput mortuum* burnt to ashes, proves that Milk still retains something of the vegetable nature; for the following analysis will shew us that matters purely animal yield none at all.

C H A P. II.

OF THE SUBSTANCES WHICH COMPOSE AN ANIMAL BODY.

P R O C E S S I.

Blood analyzed. Instanced in Bullock's Blood.

IN a *balneum mariæ* evaporate all the moisture of the Blood that the heat of boiling water will carry off. There will remain an almost dry matter. Put this dried Blood into a glass retort, and distill with degrees of heat, till nothing more will come over,

over, even when the retort is quite red-hot, and ready to melt. A brownish phlegm will rise at first: this will soon be impregnated with a little Volatile Alkali, and then will come over a yellow Oil, a very pungent Volatile Spirit, a Volatile Salt in a concrete form, which will adhere to the sides of the receiver; and, at last, a black Oil, as thick as pitch. There will be left in the retort a charred matter, which being burnt, yields no Fixed Alkali.

OBSERVATIONS.

BLOOD, which is carried by the circulation into all the parts of the animal body, and furnishes the matter of all the secretions, must be considered as a liquor consisting of almost all the fluids necessary to the animal machine: so that the analysis thereof is a sort of general, though imperfect, analysis of an animal.

Blood drawn from the body of an animal, and set by in a vessel, coagulates as it grows cold; and some time afterwards the *coagulum* discharges a yellowish *Serum* or lymph; and in the midst thereof swims the red part, which continues curdled. These two substances, when analyzed, yield nearly the same principles; and in that respect seem to differ but little from each other. Though the Serum of Blood be naturally in a fluid form, yet it hath also a great tendency to coagulate, and a certain degree of heat applied to it, either by water, or by a naked fire, will curdle it. Spirit of Wine mixed with this liquor produces on it the same effect as heat.

Blood, while circulating in the body of a healthy animal, and when newly taken from it, hath a mild taste, which discovers nothing like either an Acid or an Alkali; nor doth it shew any sign of either the one or the other in Chymical trials. When tasted with attention it betrays something like a
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flavour of Sea-salt; because it actually contains a little thereof, which is found in the charred matter left in the retort after distillation, when carefully examined.

We shewed that Milk also contains a little of this Salt. It enters the bodies of animals with the food they eat, which contains more or less thereof, according to its nature. It plainly suffers no alteration by undergoing the digestions, and passing through the strainers, of the animal body. The case is the same with the other Neutral Salts which have a Fixed Alkali for their basis: we find them unchanged in the juices of animals into whose bodies they have been introduced. They are incapable of combining, as Acids do, with the oily parts; and so are dissolved by the aqueous fluids, of which nature makes use to free herself from those Salts, and discharge them out of the body; as shall be shewn when we come to speak of Urine and Sweat.

Blood, like all other animal matters, is, properly speaking, susceptible of no fermentation but that of putrefaction. Yet it turns somewhat sour before it putrefies. This small degree of acetous fermentation is most sensible, in flesh; and especially in the flesh of young animals, such as calves, lambs, chickens, &c.

The quantity of pure water, which blood, in its natural state contains, is very considerable, and makes almost seven eighths thereof. If it be distilled, without being first dried, the operation will be much longer; because it will be necessary to draw off all this insipid phlegm with a gentle fire. There is no reason to apprehend, that, by drying Blood in open vessels as directed, any of its other principles will be carried off with its Phlegm: for it contains no other substance that is volatile enough to rise with the warmth of a *balneum marie*. This may be proved by putting some undried Blood into a glass cucurbite,

cucurbite, fitting thereto a head and receiver, and distilling, in a *balneum mariæ*, all that the heat of the bath, not exceeding the heat of boiling water, will raise; for, when nothing more will come over, you will find in the receiver an insipid phlegm only, scarce differing from pure water, except in having a faint smell like that of Blood; wherein it resembles all the phlegms that rise first in distillation, which always retain something of the smell of the matters from which they were drawn. That part of the Blood, which remains in the cucurbite, after this first distillation, being put into a retort, and distilled with a stronger fire, yields exactly the same principles, and in the same proportion, as Blood dried in open vessels, in the *balneum mariæ*: so that, if this Phlegm of Blood contain any principles, the quantity thereof is so small as to be scarce perceptible.

The Volatile Alkali that rises with the Oil, when Blood is distilled in a retort with a degree of heat greater than that of boiling water, is either the production of the fire; or arises from the decomposition of an Ammoniacal Salt, of which it made a part. For we shall see, when we come to treat of this saline substance, that it is so extremely volatile as to exceed, in that respect, almost all other bodies that we know: and therefore if this Volatile Alkali pre-existed formally in the Blood, uncombined with any other matter capable, in some measure, of fixing it, it would rise at first almost spontaneously, or at least on the first application of the gentlest heat. We have an instance of this in Blood, or any other animal matter, that is perfectly putrefied; which containing a Volatile Alkali, either formed or extricated by putrefaction, lets go this principle when distilled, even before the first phlegm: and, for this reason, when putrefied Blood is to be analyzed, it must by no means be dried, like fresh Blood, before distilla-

distillation; for all the Volatile Alkali would by that means be dissipated and lost at once.

The Volatile Alkali obtained from Blood that hath not undergone putrefaction, affords matter of some speculation. Indeed the separation of this Salt from Blood requires a degree of heat vastly greater than that which is necessary to make it rise, when it is perfectly formed and disentangled: and this gives room to think that it is the result of a combination formed by the fire, during the distillation. But then this same degree of heat neither separates nor forms any Volatile Alkali in a great number of plants, or in milk, as hath been shewn. Yet it cannot be supposed that the Blood of animals, which feed only on those plants or on milk, is any other than these very matters digested and rendered perfectly animal substances; whence it must be concluded, that, when vegetable substances are converted into animal substances, they undergo such alterations as render them capable of yielding, when analyzed, a principle that was not discoverable in them before. Now we know that this same principle, that is, the Volatile Alkali, is the product of putrefaction, or, which is the same thing, of the last degree of fermentation: and this, I think, makes the opinion of those more than probable, who believe that trituration and mechanical motion are not the only causes that effect the conversion of food into animal juice, but that fermentation hath a great share in this change. It is true, we do not find, in animal matters, any manifest token of an Ardent spirit, an Acid, or a Volatile Alkali; nor, consequently, any substance that is an evident production of any of the three different degrees of fermentation; and yet, as substances perfectly animalized are exactly in the same state with vegetables that have undergone the first, and even the second, de-

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gree of fermentation, so that they are susceptible of putrefaction only; (or, at least, if they shew at first some faint tokens of acidity, they run immediately and rapidly into complete putrefaction;) it is nevertheless probable that vegetable matters, in order to their becoming animal substances, undergo certain changes and alterations, which have some resemblance with those produced by fermentation.

This opinion is further confirmed by two other analogies, between animal matters, and vegetables advanced to the last stage of fermentation; which is, that they yield neither an Essential Oil, nor a Fixed Alkali: for the coal, that remains in the retort after the distillation of Blood, being burnt in an open fire, discovers no Fixed Alkali in its ashes.

The want of a Fixed Alkali in animal matters arises from hence, that their Acid is nearly in the same state with the Acid of vegetable matters which have undergone putrefaction; that is, it is so subtilized and attenuated, as to be fit to enter into the combination of a Volatile Alkali, and is no longer so intimately united with the fixed earth as to produce therewith a Fixed Alkali in the fire.

Though Blood and other animal matters afford no Fixed Alkali, but, on the contrary, yield much Volatile Alkali, it doth not therefore follow, that all the Acid, which those substances contained before they were analyzed, is employed in the production of a Volatile Alkali. We shall hereafter take notice of an animal matter which contains a great deal of Acid: and, not to depart from our present subject, it doth not appear to me to be a settled point among Chymists, whether or no Blood, when analyzed, yields a portion manifestly Acid, and possessing all the properties of an Acid.

Mr. Boerhaave, with some other Chymists, makes no mention of any Acid in his analysis of Blood.

Mr.

Mr. Homberg, on the contrary, says * expressly, that he constantly obtained an Acid from the Blood and flesh of different sorts of animals, of which he analyzed a great number. Mr. Boerhaave's authority is very respectable, and of great weight: on the other hand, Mr. Homberg's experiments are very conclusive, seem to be made with great care, and are all affirmative. This apparent diversity in the same analysis, delivered by these two great men, determined me to analyze Blood myself, and to examine scrupulously all the principles I could obtain from it.

I therefore distilled some Bullock's Blood in a retort with degrees of fire. Some Phlegm came over first, and then a Volatile Spirit. I changed my receiver; and on increasing the fire there rose, with the Volatile Spirit, a yellow Oil, a Volatile Salt in a concrete form, a ruflet liquor which smelled strong of Volatile Alkali, and seemed at first to be only a Spirit impregnated with much of that Salt: at last came a very thick fetid Oil.

In this brown liquor, which comes off towards the end of the distillation, Mr. Homberg affirms the Acid to be contained; but, as it certainly is replete with a Volatile Alkali also, he alledges that it contains, at the same time, both a Volatile Alkali and the animal Acid; that these two Salts are distinct from each other, and not combined together in the form of an Ammoniacal Salt; that each of consequence possesses its peculiar properties; and that this liquor is at the same time both Acid and Alkaline; that it effervesces with Acids, and also changes the blue colours of plants to red.

The Alkaline quality of this liquor is very evident, and discovers itself in every Chymical trial; but the same cannot be said of its Acid property. I dropped some of it on blue paper, the colour of

* Memoirs of the Academy of Sciences for 1712.

which did not at first change in the least, nor acquire the faintest shade of redness. This experiment almost determined me to conclude that Mr. Homberg was mistaken: but some time afterwards I perceived that the blue paper began to turn red where it had been wetted, and that the red colour grew deeper and deeper as the paper dried: and this convinced me that this liquor actually contains an Acid, as Mr. Homberg asserted; but, that the Volatile Alkali in this liquor, being much more copious than the Acid, had first entered the paper, and hindered the Acid from turning it red as usual; and that, as the Alkali evaporated, the Acid began to act, and produce the customary effect. Hence we see that the Acid of Blood, though extricated by distillation, is not easily perceived at first, because of the great proportion of Volatile Alkali, with which the liquor containing it is impregnated. This is probably what prevented its being discovered by several Chymists, who, it seems, did not suspect its existence, and therefore did not look for it.

Mr. Homberg takes no notice of this little difficulty in his Memoir: but he relates an experiment which might have given occasion to suspect it. It is in his analysis of Human Blood. As the Acid in Human Blood is in less quantity, and less perceptible, than in the Blood of animals that live wholly on vegetables, he directs a second distillation of the brown liquor, which contains at once both the Volatile Alkali and the Acid, till very little thereof be left in the retort. *This residuum*, says he, *contains a very perceptible and distinct Acid*. There is reason to believe, from Mr. Homberg's directing the saline liquor to be distilled again, that he did not find the Acid sufficiently perceptible in it at first. Now a second distillation is a very good way to render it much more sensible. For though this animal Acid be volatile, the Volatile Alkali is still vastly more so; and

and therefore if the liquor containing both these saline substances be distilled, the Volatile Alkali must needs rise first, and leave the Acid alone, or almost alone, at the bottom of the retort. This is exactly the case in our experiment on blue paper; the operation being here performed with a small quantity, and much more expeditiously, as appears from our account of it:

It is not at all surprizing that the Volatile Alkali and animal Acid, though confounded in the same liquor, should not be united together and converted into a Neutral Ammoniâcal Salt. Mr. Homberg pretends that these two saline matters do not act upon each other, because they are too much dephegmated. The oily parts, with which they are both loaded, may also contribute thereto: nor is this unprecedented; the same thing being observed of the Acid and the Volatile Alkali of several vegetable substances.

Mr. Homberg, justly suspecting that there might be some difference between the condition of the Acid in the Blood of animals that feed altogether on vegetables, and that in the blood of those that feed only on flesh, examined likewise, by decomposition, the Blood and the flesh of some carnivorous animals. In these also he found an Acid; and it doth not appear that he observed any great difference, in this respect, between their Blood and that of other animals. The difference he found between the Blood of young, or that of grown, or old, animals, with respect to the Acid, seems, by his account, to be more considerable; the Blood of the former containing much more of it than that of the latter: and this is so much the more probable, as we know that the flesh of young animals grows sour, before it putrefies, more sensibly than that of old ones.

We shall conclude this head with a remark concerning the management required in distilling Blood.

When the operation is advanced to a certain point, the matter contained in the retort often swells so as to stop the neck of that vessel entirely, and by that means makes it burst with an explosion. To avoid this inconvenience, a very small quantity of Blood must be put into the retort, and the fire must be governed very warily. I have also found that this accident may generally be prevented by mixing the Blood with some matter that can afford no principle by distillation; such as pounded glass or fine sand.

PROCESS II.

Flesh analyzed. Instanced in Beef.

INTO an alembic or retort, placed in a sand-bath, put some lean beef, from which you have carefully separated all the fat. Distill till nothing more will rise. In this first distillation a phlegm will come over, weighing at least half the mass of the distilled flesh. In the retort you will find a matter almost dry, which you must afterwards distill, with a naked fire, in a reverberating furnace, taking the usual precautions. There will come over at first a little phlegm replete with Volatile Alkali; then a Volatile Alkali in a dry form, which will stick to the sides of the vessel; and also a thick Oil. After the distillation there will be left in the retort a black, shining, light coal. Burn it to ashes in the open air, and lixivate those ashes; the water of the lixivium will have no Alkaline property, but will shew some tokens of its containing a little Sea-salt.

OBSERVATIONS.

THIS analysis of Beef is taken from a Memoir given in by Mr. Geoffroy in 1730, the purpose of which was a Chymical examination of the meat commonly

monly used to make broth. The flesh of an animal, as appears from the process, yields much the same principles with its Blood: and it cannot be otherwise; because it is formed altogether of materials furnished by the Blood.

Mr. Geoffroy observes that the first phlegm, drawn off from it in the *balneum mariæ*, produces a white precipitate in a solution of Corrosive Sublimate; which shews it to contain a little Volatile Alkali: but the quantity thereof must be very small; seeing the phlegm that contains it smells only like broth, and not like a Volatile Alkali; one particle of which we know, is capable of affecting the organ of smelling very sensibly. As to the Acid of flesh, there is great reason to believe that it is conditioned exactly like that of Blood.

The ashes of the *caput mortuum* of flesh, burnt in an open fire, attract the moisture of the air, as Mr. Geoffroy remarks, and increase in weight, though they contain no Fixed Alkali. However, this is not at all surprising; since they contain some Sea-salt; the known property whereof is to grow moist in the air.

The flesh of animals contains much matter that is soluble in water. Mr. Geoffroy examined separately that part of flesh which water is capable of dissolving. With this view he boiled four ounces of beef with three pints of water, in a very close vessel, and repeated the operation six times with equal quantities of fresh water; in order to extract, as far as possible, all the juices of the meat. These broths he put all together, the last of them having but a faint smell of very weak veal broth: he evaporated them over a slow fire, filtering them towards the end of the evaporation, to separate an earthy part; and there remained in the vessel a moderately solid extract, which soon grew moist in the air. This extract,

being analyzed, yielded a dram and two grains of Volatile Salt, which adhered to the sides of the receiver; not in ramifications, as Volatile Salts usually do, but in flat crystals, mostly in the form of parallelepipeds. The Spirit and the Oil, which came over together after the Volatile Salt, weighed thirty-eight grains. Salt of Tartar being mixed with this Volatile Salt seemed to increase its strength; which gives room to suspect that the latter contains an Ammoniacal Salt.

The charred matter left in the retort weighed but six grains. Its lixivium gave some tokens of Sea-salt, by making a white precipitate in a solution of quick-silver. The mass of fleshy fibres, that was exhausted by boiling, being dried and analyzed in the same manner, yielded a Volatile Spirit, a Volatile Salt in a concrete form, which stuck to the sides of the receiver in ramifications as usual; and a thick fetid Oil. There now remained in the retort a charred matter, which being burnt in the open air, or not burnt, shewed not the least sign of its containing any saline matter.

This method of analyzing flesh, by boiling it at first in water, in order to extract all that can be dissolved by this menstruum, shews us that animal flesh contains an Oil, which is in a saponaceous state; for the extract made therefrom, by water, yields in distillation a considerable quantity of Oil, which was perfectly dissolved in the water, while that extract was in the diluted state of broth, and before it was analyzed.

It is remarkable that the Volatile Salt, yielded by the extract of flesh, is different from that which is obtained out of the flesh itself, when nothing hath been extracted from it. This Salt, as Mr. Geoffroy observed, differs from the common Volatile Alkalis in the form of its crystals; which made that Chymist
justly

justly consider it as a Salt of a somewhat Ammoniacal nature; a kind of Essential Salt of Flesh.

There is reason to think that this Salt, when dissolved in the water in which we boil flesh, is separated therefrom, by the action of fire, with more ease than while it remains combined with the other principles, in the substance of the flesh; that its separation, in the latter case, requiring a greater degree of heat, it is thereby decomposed; and that the Volatile Alkali, which is obtained from flesh distilled in the usual manner, is only one of the parts that constituted the Ammoniacal Salt thereby decomposed.

The charred matter remaining, after the distillation of flesh first exhausted by boiling, yields nothing saline; because the Sea-salt, which is the only Fixed Salt it could contain, was dissolved by the water, together with the matter of the extract.

Mr. Geoffroy likewise examined what parts of flesh Spirit of Wine is capable of dissolving. For this purpose he took four ounces of Beef, dried in the *balneum marie*, poured on it an equal weight of well-rectified Spirit of Wine, and left the whole in digestion for a considerable time. The Spirit extracted from the Beef a weak tincture, and separated from it some drops of Oil: it acquired a brown colour, and a faint smell. Mr. Geoffroy found, by several experiments, that the Spirit of Wine had taken up a portion of the Ammoniacal, or Essential, Salt of the flesh. With respect to the Oil, if any at all were dissolved, it could be but very little; for that which the Spirit separated, and which retained its natural form, was certainly not dissolved: seeing in that case it would not have been perceived, but would have made a homogeneous liquor, to appearance, with the Spirit of Wine.

PROCESS III.

Bones analyzed. Instanced in Ox-bones.

CUT into pieces the Bones of a leg of beef, carefully separating all the marrow. Put them into a retort, and distill them in a reverberating furnace, as usual. A Phlegm will come over first; then a Volatile Spirit, which will become stronger and stronger; afterwards a Volatile Salt in a dry form, with some Oil; and, lastly, a black Oil, with a little more Volatile Salt. There will be left in the retort a charred matter, from which a little Sea-salt may be extracted. Reduce this charred matter to ashes, by burning it in the open air. These ashes will give some slight tokens of a Fixed Alkali.

OBSERVATIONS.

THE analysis of Bones proves that they consist of the same principles with flesh and blood; and the same may be said, in general, of all matters that are truly animal, or that actually constitute any part of an animal.

Nevertheless we find in the ashes of Bones somewhat of an Alkaline quality; seeing they make a red precipitate in a solution of Corrosive Sublimate: and yet a true Fixed Alkali cannot be obtained from them. These ashes are probably in the same case with quick-lime; which hath certain properties of Alkaline Salts, though no Salt of that kind can be extracted from them.

Mr. Geoffroy analyzed Bones in the same manner as he did flesh; that is, he at first made a strong decoction of them with water, and then examined and distilled apart the extract afforded him by that decoction, and the Bones deprived of that
extract.

extract. On this analysis he made two remarkable observations.

The first is, that Bones yielded to boiling water their principles and their Volatile Salts, both sooner and more copiously than flesh did: for in the analysis which Mr. Geoffroy made of several sorts of flesh, though he robbed them in a manner of all their principles by boiling, yet their dried fibres afterwards yielded a considerable quantity of Volatile Salt; whereas the Bones, of which he had made an extract by boiling, afforded him but a very small quantity thereof when analyzed.

The second observation worthy of notice which Mr. Geoffroy made on his analysis of Bones is this; the Salt, which, as was shewn in the analysis of flesh, was resolved by the water wherein he boiled the flesh, and consequently rose when he distilled the extract obtained from that decoction, and crystallized in the form of parallelpipeds, took a quite different turn in the analysis of Bones. None of it appeared in distilling the extract made by decoction, but rose in distilling the boiled Bones that were exhausted of almost all their other principles by the decoction with water. These differences probably arise from the different contexture of the animal matters in which they are observed.

This analysis of Bones may serve as a pattern for analyzing all the solid parts of animals, such as horns, hoofs, ivory, &c.

PROCESS IV.

Animal Fat analyzed. Instanced in Mutton Suet.

PUT as much Mutton-Suet as you please into a glass retort, only taking care that the vessel be but half-full; and distill with degrees of fire as usual. A Phlegm smelling of the Suet will rise first, and soon grow very acid. After this some drops of Oil will come over, and be followed by a matter like Oil, in appearance, when it comes over; but it will fix in the receiver, and acquire a consistence somewhat softer than Suet. This kind of Butter of Suet will continue to rise to the end of the distillation; and there will be left in the retort a small quantity of charred matter.

OBSERVATIONS.

THOUGH animal Fat be a substance that hath passed through all the strainers of the body; though it hath undergone all the elaborations necessary to form an animal matter, and become itself part of the animal; it contains, nevertheless, as its analysis shews, principles differing greatly from those of all other animal matters; so that it must be classed, in some sort, by itself.

It consists almost entirely of Oil: but this Oil is in a concrete form, and observes the general rule of all concreted oily matters, which owe their consistence wholly to the Acid that is combined with them. The rule is evidently so general, that it extends even to the animal kingdom; where in all other instances, Acids seem to be almost annihilated.

All we said above on the subject of Butter must be applied here: for animal Fat, properly so called, and Butter, do not, in my opinion, differ sensibly from each other, with respect to their analysis. And there-

therefore there is great reason to believe that what is Butter in Chyle, or Milk, becomes Fat when fixed in the animal body. It is a kind of repository, in which nature lays up and confines the Acid that is unnecessary to the animal composition, and which she could not any other way eliminate.

I made choice of Mutton-Suet for an instance of the analysis of Fat; because this Fat, being the firmest of any, must contain a stronger and more perceptible Acid.

When it is thus distilled, the part which remains fixed hath much less consistence than the Suet had before; which arises from its having lost part of its Acid. Repeated distillations will deprive it of a much greater quantity thereof, and so reduce it into an Oil that will always remain clear and fluid.

Not one particle of Volatile Alkali is obtained by distilling Suet: but then the experiment will not succeed as it ought, unless care be taken to free the Suet perfectly from all the membranes, and all the particles of flesh and blood that may be mixed with it: for, if it should be distilled without this precaution, those heterogeneous matters mingled with it would yield a great deal of Volatile Alkali in distillation; which might impose on the Artist, and make him think the Salt came actually from the Suet. Suet that hath been often melted, as the tallow, for instance, of which candles are made, is sufficiently purified: of this I made use in my analysis, and it yielded me no Volatile Alkali; at least I could perceive none.

In conclusion, all that hath been said, on several occasions, touching the properties of concreted oily matters, may be applied to Suet. I shall only observe here that it is one of those that manifest no Acidity, and consequently that in its natural state it is not soluble in Spirit of Wine, and only becomes soluble in that menstruum by degrees, as its Acid

is extricated by repeated distillations: and on this account it ought to be classed with Bee's-Wax, and other oily compounds of that kind.

PROCESS V.

Eggs analyzed. Instanced in Pullet's Eggs.

PUT some Hen's Eggs in water, and boil them till they be hard. Then separate the Yelks from the Whites. Cut the Whites into little bits; put them into a glass cucurbite; fit on a head and receiver; distill in a *balneum mariae* with degrees of fire, raising it towards the end to the strongest heat which that bath can give; that is, to the heat of boiling water. There will come over an aqueous liquor, or insipid phlegm; the quantity whereof will be very considerable, seeing it will make about nine tenths of the whole mass of the Whites of the Eggs. Continue your distillation, and keep the water in the bath constantly boiling, till not a drop more of liquor will ascend from the alembic. Then unlute your vessels. In the cucurbite you will find your Whites of Eggs considerably shrunk in their bulk. They will look like little bits of brown glass, and be hard and brittle.

Put this residuum into a glass retort, and distill, as usual, in a reverberating furnace with degrees of heat. There will come over a Volatile Oily Spirit, a yellow Oil, a Volatile Salt in a dry form, and, at last, a black thick Oil. There will be left in the retort a charred matter.

Reduce also into the smallest pieces you can the hard Yelks of the Eggs which you separated from the Whites. Set them in a pan over a gentle fire: stir them with a stick till they turn a little brown, and discharge a substance like melted marrow.

Then

Then put them into a new strong canvass bag, and press them between two iron plates well heated; whereby you will obtain a considerable quantity of a yellow Oil.

Let what remains in the bag be distilled in a retort set in a reverberating furnace: it will give you the same principles as you got from the Whites.

OBSERVATIONS.

Of the two perfectly distinct substances that constitute the Egg, the Yelk contains the embryo of the chick, and is destined to hatch it: the White is to serve for the nourishment of the chick when it is formed.

These two matters, though they contain the very same principle, yet differ considerably from each other; and chiefly in this, that their principles are not in the same proportions.

The White of an Egg contains so much phlegm, that it seems to consist almost totally thereof. All the aqueous liquor, obtained by distilling it in the *balneum mariæ*, is, properly speaking, nothing but pure water: for no Chymical trial can discover in it either an Acid or a Volatile Alkali; or any very perceptible Oily part. And yet it must contain some Oil, because the liquor that rises last is a little bitterish to the taste, and smells somewhat of empyreuma. But the principles from which it derives these properties are in too small quantities to be distinctly perceived.

If, instead of distilling the hard White of an Egg, with a view to draw off the great quantity of water it contains, you leave it some time in an air that is not too dry, the greatest part of its moisture separates spontaneously, and becomes very sensible. In all probability this is the effect of a beginning putrefaction, which attenuates this substance, and breaks its contexture. The liquor thus discharged by the

White of an Egg, thoroughly dissolves Gum-Resins, and particularly Myrrh. If you desire to dissolve Myrrh in this manner, cut a hard-boiled Egg in halves: take out the Yelk; put the powdered Gum-Resin into the cavity left by the Yelk; join the two halves of the White; fasten them together with a thread, and hang them up in a cellar. In a few days time the Myrrh will be dissolved by the moisture that issues from the White of the Egg, and will drop into the vessel placed underneath to receive it. This liquor is improperly called *Oil of Myrrh per deliquium*.

All the properties of the Whites of Eggs, as well as the principles obtained by analyzing them, are the same with those of the lymphatic part of the blood; so that there is a great resemblance between these two substances.

As to the Yelk, it is plain from its analysis that Oil is the predominant principle thereof. If the Yelk of an Egg be mixed with water, the Oil with which it is replete, and which is by nature very minutely divided, diffuses itself through the whole liquor, and remains suspended therein by means of its viscosity. The liquor at the same time becomes milk-white like an emulsion, and is in fact a true animal emulsion.

In order to obtain the Oil of Eggs by expression with the more ease, care must be taken to chuse Eggs that are seven or eight days old; because they are then a little less viscous. Nevertheless their viscosity is still so great that they will not easily yield their Oil by expression: and therefore, in order to attenuate and destroy entirely this viscosity, they must be torrefied before they are put to be pressed.

The Oil of Eggs, like all other oily animal matters, seems analogous to the Fat Oils of vegetables. It hath all the properties that characterise those
Oils.

Oils. Its colour is yellow, and it smells and tastes a little of the empyreuma, occasioned by torrefying the Yelks. It is rendered somewhat less disagreeable by being exposed to the dew for thirty or forty nights, if care be taken to stir it often in the mean time.

To conclude : all the principles, both in the Yelk and the White of an Egg, are the same as those found in Blood, Flesh, and all other matters that are perfectly animal.

C H A P. III.

OF THE EXCREMENTS OF ANIMALS.

P R O C E S S I.

*Dung analyzed. Instanced in Human Excrement.
Mr. Homberg's Phosphorus.*

TAKE any quantity you please of human Excrement, and distill it in a glass alembic set in the *balneum mariæ*. You will obtain an aqueous, clear, insipid liquor : which will nevertheless have a disagreeable odour. Having urged the distillation as far as is possible, with the heat of this bath, unite your vessels, and you will find at the bottom of the cucurbite a dry matter, making about an eighth part only of what you put into it. Put this residuum into a glass retort, and distill in a reverberating furnace, with degrees of heat. You will obtain a Volatile Spirit, and a Volatile Salt, with fetid Oil ; and a charred matter will be left in the retort.

OBSERVATIONS.

Mr. HOMBERG made a great many experiments on the dung of animals; concerning which he composed two Memoirs published in the Academy's collection for 1711. That Chymist tells us, that, in distilling Excrement, he aimed not so much at discovering the principles of which it consists, as he was desirous to satisfy a friend of his who had earnestly entreated him to try whether he could not extract therefrom a clear Oil, having no bad smell; because he had seen, as he said, Mercury fixed into pure Silver by such an Oil.

Mr. Homberg's labour had the usual fate of all enterprizes of this nature. He actually found the art of drawing from Excrement a clear scentless Oil; but, in whatever way he applied it to Mercury, it produced no change in that metallic substance. However, as Mr. Homberg was a man of sagacity, and knew how to improve every hint offered by his experiments, he made several curious discoveries on this occasion; of which we shall give a concise account, after we have made some remarks on the principles obtained from Excrement by the method described in the process.

This substance, consisting of matters subject to putrefaction, hath constantly a fetid smell, like that of all putrid matters; having been for some time confined in a warm moist place, which we know promotes putrefaction, and even quickly produces it. Yet the analysis thereof proves that it is not putrefied, or at least not entirely so: for all putrefied matters contain a Volatile Alkali perfectly formed and extricated; and, as this principle rises with less heat than that of boiling water, it always comes over first in distillation. Now we have seen that, with the heat of boiling water, it parts with nothing but an insipid phlegm, containing no Volatile

latile Alkali : a sure proof that the fecal matter is not completely putrefied.

There is nothing remarkable in the Volatile Salt and fetid Oil, which rise with a degree of heat greater than that of boiling water. They are common productions, of which we have made frequent mention in several of the preceding analyses ; and therefore they need not now detain us from proceeding to give a summary account of Mr. Homberg's chief discoveries.

One of the methods by which Mr. Homberg endeavoured to obtain from Excrement a clear Oil, without any bad smell, was to separate its earthy and gross parts, by filtering it before he distilled it. " For this purpose he diluted Excrement newly " discharged with hot water, using a quart of water " to an ounce of feces. Then he let the mixture " stand to cool, and, the gross parts falling to the " bottom, he poured off the water by inclination. " This liquor he filtered through brown paper, " and evaporated to a pellicle over a gentle fire. " There shot in it long crystals of four, five, and six " sides, which Mr. Homberg thinks may be called " the Essential Salt of Excrement. They resemble " Saltpetre, in some measure, and desflagrate in the " fire much like it ; with this difference, that their " flame is red, and they burn slowly ; whereas the " flame of Saltpetre is white and very vivid : probably, says Mr. Homberg, because there is too " much of an oily matter in the one, and less in " the other.

" Mr. Homberg distilled this Salt in a glass retort with degrees of fire, and at last with a very " violent one. At first there came over an aqueous liquor, sharp and acid, which was followed " by a brown fetid Oil, smelling very strong of empyreuma. This distillation he attempted four " several times ; and each time the matter in the

“ retort took fire, just when the Oil began to come
“ off.”

The Salt which Mr. Homberg obtained from Excrement is very remarkable. We shall have occasion to speak of it in another place, and shall only observe here, that its Nitrous character is by no means ambiguous: its deflagrating on live coals convinced Mr. Homberg of its being a true Nitre. But its constantly taking fire in the retort, as oft as distilled, is a sure proof that it is a Nitrous Salt: for Nitre only hath the property of thus taking fire in close vessels, and making other combustible matters burn along with it.

The process by which Mr. Homberg at last obtained from Excrement a clear Oil without any bad smell is curious, and worthy of a place here; on account of the views and occasions of reflection which it may open.

“ Mr. Homberg having tried in vain, by distil-
“ ling Excrement a great many different ways, to
“ obtain from it such an Oil as he wanted, resolved
“ to employ fermentation, the effect whereof is to
“ change the disposition of the principles of mixts.
“ With this view he dried some Excrement in the
“ water-bath, and, having pulverized it, poured
“ thereon six times its weight of phlegm that had
“ been separated from it by distillation, and put the
“ whole into a large glass cucurbite, covered with
“ an inverted vessel that fitted exactly into it, and
“ was close luted. This vessel he set in a *balneum*
“ *mariae* for six weeks, keeping up such a gentle
“ heat as would not burn one’s hand; after which
“ he uncovered the cucurbite, and having fitted
“ thereto a head and a receiver, distilled off all the
“ aqueous moisture in the *balneum mariae* with a
“ very gentle heat. It had now lost almost all its
“ bad smell, which was changed into a faint one.
“ It came over somewhat turbid, whereas it was
“ very

“ very clear when put into the cucurbite. Mr.
 “ Homberg found this water to have a cosmetic
 “ virtue: he gave some of it to persons whose com-
 “ plexion, neck, and arms, were quite spoiled, be-
 “ ing turned brown, dry, rough, and like a goose
 “ skin: they washed with it once a day, and, by
 “ continuing the use of this water, their skin be-
 “ came very soft and white.”

The dry matter, that remained in the bottom of the cucurbite after distillation, had lost about a twentieth part of its weight; that is, of twenty ounces, put at one time into the cucurbite, somewhat less than nineteen ounces remained. Mr. Homberg suspects that it was not so dry when put into the cucurbite as when it was taken out. Perhaps also the species of fermentation which the matter underwent had attenuated and volatilized some part of it; so that it came over with the phlegm in distillation. The turbidness of that phlegm, which was clear and limpid before, seems to countenance this conjecture.

“ The dry matter left in the cucurbite after the
 “ first distillation had not the least smell of feces:
 “ on the contrary, it had an agreeable aromatic
 “ odour; and the vessel in which Mr. Homberg had
 “ digested it, being left open in a corner of his la-
 “ boratory, acquired in time a strong smell of Am-
 “ berggris. It is surprising, as Mr. Homberg justly
 “ observes, that digestion alone should change the
 “ abominable smell of Excrement into an odour as
 “ agreeable as that of Ambergris.

“ This dry matter he powdered coarsely, and
 “ put two ounces thereof at once into a glass re-
 “ tort, that would hold about a pound or a pound
 “ and half of water. This he distilled in a sand-
 “ bath with a very gentle heat. A small quantity
 “ of an aqueous liquor came over first, and then
 “ an Oil as colourless as spring-water. Mr. Hom-
 “ berg

“ berg continued the same gentle degree of heat,
 “ till the drops began to come off a little redish;
 “ and then he changed the receiver, stopping that
 “ which contained the clear Oil very close with a
 “ cork. Having carried on the distillation with
 “ a fire gradually augmented, there came over a
 “ considerable quantity of red Oil; and there re-
 “ mained in the retort a charred matter, which
 “ burnt very readily.”

The clear Oil, without any ill smell, which Mr. Homberg obtained from the fecal matter by this process, was the very thing he was in search of, and which he had been assured would convert Mercury into fine fixed Silver; yet he ingenuously owns, that, whatever way he applied it, he could never produce any change in that metallic substance. We shall now proceed to the other discoveries made by Mr. Homberg on this occasion.

In his attempt to obtain a clear Oil from Excrement, he distilled it with different additaments, and amongst the rest with Vitriol and Alum. He found that the matters left in the retort, when he made use of these Salts, being exposed to the open air, took fire of themselves; that they kindled combustible matters; in a word, that they were a true Phosphorus, of a species different from all then known. Pursuing these first hints, he sought and found the means of preparing this Phosphorus by a way much more expeditious, certain, and easy. His process is this.

“ Take four ounces of Feces newly excreted:
 “ Mix therewith an equal weight of Roch-Alum
 “ coarsely powdered: put the whole into a little
 “ iron pan that will hold about a quart of water,
 “ and set it over a gentle fire under a chimney.
 “ The mixture will melt, and become as liquid as
 “ water. Let it boil with a gentle fire, constantly
 “ stirring it, breaking it into little crumbs, and
 “ scraping

“ scraping off with a spatula whatever sticks to the
 “ bottom or sides of the pan, till it be perfectly
 “ dry. The pan must from time to time be re-
 “ moved from the fire, that it may not grow red-
 “ hot, and the matter must be stirred, even while
 “ it is off the fire, to prevent too much of it from
 “ sticking to the pan. When the matter is per-
 “ fectly dried, and in little clots, let it cool, and
 “ powder it in a metal mortar. Then put it again
 “ into the pan, set it over the fire, and stir it con-
 “ tinually. It will again grow a little moist, and
 “ adhere together in clots, which must be con-
 “ tinually bruised and roasted till they be perfectly
 “ dry; after which they must be suffered to cool,
 “ and then be pulverized. This powder must be
 “ returned a third time to the pan, set on the fire,
 “ roasted, and perfectly dried: after which it must
 “ be reduced to a fine powder, and kept in a paper
 “ in a dry place. This is the first or preparatory
 “ operation.

“ Take two or three drams of this powder. Put
 “ it into a little matrafs, the belly of which will
 “ hold an ounce, or an ounce and an half of water,
 “ and having a neck about six or seven inches
 “ long. Order it so that your powder shall take up
 “ no more than about a third part of the matrafs.
 “ Stop the neck of the matrafs slightly with paper:
 “ then take a crucible four or five inches deep: in
 “ the bottom of the crucible put three or four
 “ spoonfuls of sand: set the matrafs on this sand,
 “ and in the middle of the crucible, so as not to
 “ touch its sides. Then fill up the crucible with
 “ sand, so that the belly of the matrafs may be
 “ quite buried therein. This done, place your cru-
 “ cible, with the matrafs, in the midst of a little
 “ earthen furnace, commonly called a *Stove*, about
 “ eight or ten inches wide above, and six inches

“ deep from the mouth to the grate. Round the
“ crucible put lighted coals about half way up, and
“ when it hath stood thus half an hour, fill up with
“ coals to the very top of the crucible. Keep up
“ this fire a full half-hour longer, or till you see the
“ inside of the matrafs begin to be red. Then
“ increase your fire, by raising your coals above the
“ crucible. Continue this strong heat for a full
“ hour, and then let the fire go out.

“ At the beginning of this operation dense fumes
“ will rise out of the matrafs, through the stopple
“ of paper. These fumes issue sometimes in such
“ abundance as to push out the stopple; which you
“ must then replace, and slacken the fire. The
“ fumes cease when the inside of the matrafs begins
“ to grow red; and then you may increase the fire
“ without any fear of spoiling your operation.

“ When the crucible is so cold that it may be
“ safely taken out of the furnace with one's hand,
“ you must gradually draw the matrafs out of the
“ sand, that it may cool slowly, and then stop it
“ close with a cork.

“ If the matter at the bottom of the matrafs ap-
“ pear to be in powder when shaken, it is a sign the
“ operation hath succeeded: but if it be in a cake,
“ and doth not fall into powder on shaking the
“ matrafs, it shews that your matter was not suf-
“ ficiently roasted and dried in the iron pan, during
“ the preparatory operation.”

Since Mr. Homberg, Mr. Lemerî the younger
hath made a great many experiments on this Phos-
phorus, which may be seen in the Memoirs of the
Academy for 1714 and 1715. In those Memoirs
Mr. Lemerî hath shewn that Excrement is not the
only matter capable of producing this Phosphorus
with Alum; but that, on the contrary, almost all
animal and even vegetable matters are fit for this

com-

combination; that though Mr. Homberg mixed Alum in equal quantities only with the fecal matter, it may be used in a much greater proportion, and in certain cases will succeed the better; that, according to the nature of the substances to be worked on, the quantity of that Salt may be more or less increased; and that whatever is added, more than the dose requisite for each matter, serves only to lessen the virtue of the Phosphorus, or even destroys it entirely: that the degree of fire applied must be different according to the nature of those matters; and, lastly, that Salts containing exactly the same Acid with that of Alum, or the Acid of those Salts separated from its basis and reduced into Spirit, do not answer in the present operation; which shews, says Mr. Lemerî, that many sulphureous matters may be substituted for Excrement in this operation; but that there are no Salts, or very few if any, that will succeed in the place of Alum. Nevertheless a Chymist, who lately communicated to the Academy a great number of experiments on this Phosphorus, found that any Salt containing the Vitriolic Acid may be substituted for Alum.

This Phosphorus, made either by Mr. Homberg's or by Mr. Lemerî's method, shines both by day and by night. Besides emitting light, it takes fire soon after it is exposed to the air, and kindles all combustible matters with which it comes in contact; and this without being rubbed or heated.

Mess. Homberg and Lemerî have given the most probable and the most natural explanation of the cause of the accension and other phenomena of this Phosphorus. What they say amounts in short to what follows.

Alum is known to be a Neutral Salt, consisting of the Vitriolic Acid and a calcareous earth. When this Salt is calcined with the fecal matter, or other substances abounding in Oil, the volatile principles
of

of these substances, such as their Phlegm, their Salts, and their Oils, exhale in the same manner as if they were distilled; and there is nothing left in the matrafs, when those principles are dissipated; but a charred matter, like that which is found in retorts wherein such mixts have been decomposed by distillation.

This remainder therefore is nothing but a mixture of Alum and charcoal. Now as the Acid of this Salt, which is the Vitriolic, hath a greater affinity with the Phlogiston than with any other substance, it will quit its basis to unite with the Phlogiston of the coal, and be converted by that union into a Sulphur. And this is the very case; of which we have certain proofs in the operation for preparing this Phosphorus; for when, after the volatile principles of the oily matter are drawn off, the fire is increased, in order to combine closely together the fixed parts that remain in the matrafs, that is, the Alum and the charred matter, we perceive at the mouth of the matrafs a small blue sulphureous flame, and a pungent smell of burning Sulphur. Nay, when the operation is finished, we find a real Sulphur sticking in the neck of the matrafs; and, while the Phosphorus is burning, it hath plainly a strong sulphureous smell. It is therefore certain that this Phosphorus contains an actual Sulphur; that is, a matter disposed to take fire with the greatest ease. But though Sulphur be very inflammable, it never takes fire of itself, without being either in contact with some matter that is actually ignited, or else being exposed to a considerable degree of heat. Let us then see what may be the cause of its accension, when it is a constituent part of this Phosphorus.

We mentioned just now that the Acid of the Alum quits its basis, in order to form a Sulphur by combining with the Phlogiston of the coal. This
basis

basis we know to be an earth capable of being converted into Lime; and that it is actually converted into Quick-lime by the calcination necessary to produce the Phosphorus. We know that new-made Lime hath the property of uniting with water so readily, that it thereby contracts a very great degree of heat. Now when this Phosphorus, which is partly constituted of the basis of the Alum converted into Quick-lime, is exposed to the air, the Lime instantly attracts the moisture of which the air is always full, and by this means, probably, grows so hot as to fire the Sulphur with which it is mixed. Perhaps also the Acid of the Alum is not totally changed into Sulphur: some part thereof may be only half disengaged from its basis, and in that condition be capable of attracting strongly the humidity of the air, of growing very hot likewise by imbibing the moisture, and so of contributing to the accension of the Phosphorus.

There is also room to think that all the Phlogiston of the charred matter is not employed in the production of Sulphur in this Phosphorus, but that some part of it remains in the state of a true coal. The black colour of the unkindled Phosphorus, and the red sparkles it emits while burning, sufficiently prove this. The explanation of the accension of this Phosphorus, as here given by Mess. Homberg and Lemeris, is very ingenious, and in the main just; but yet, in my opinion, the subject deserves a more thorough examination.

PROCESS II.

Human Urine analyzed.

PUT some Human Urine into a glass Alembic; set it in a water-bath, and distill till there remain only about a fortieth part of what you put in; or else evaporate the Urine, in a pan set in the *balneum mariæ*, till it be reduced to the same quantity. With this heat nothing will exhale but an insipid Phlegm, smelling however like Urine. The residuum will, as the evaporation advances, become of a darker and darker ruffet, and at last acquire an almost black colour. Mingle this residuum with thrice its weight of sand, and distill it in a retort set in a reverberating furnace, with the usual precautions. At first there will come over a little more insipid Phlegm like the former. When the matter is almost dry, a Volatile Spirit will rise. After this Spirit, white vapours will appear on increasing the fire; a yellow oily liquor will come off, trickling down in veins; and together with this liquor a concrete Volatile Salt, which will stick to the sides of the receiver. At last there will come over a deep-coloured fetid Oil. In the retort there will remain a saline earthy residuum, which being lixiviated will yield some Sea-salt.

OBSERVATIONS.

URINE must be considered as an aqueous liquor replete with all the saline matters which are of no use to the body, either for nourishment or health: it is a lixivium of animal matters, prepared by nature for dissolving and separating from them all the unnecessary salts. It contains a very large quantity of almost pure phlegm, which evaporates with the heat of a water-bath.

The

The residue of the Urine, from which this phlegm is separated by the first distillation, though thereby rendered considerably thicker, doth not coagulate, or curdle in the least, like Milk or Blood; which shews that it contains no parts analogous to those of these two nutritious liquors. Yet it contains oily and saline parts, disposed like those of truly animal matters; as appears from the Spirit, the Volatile Salt, and the Oil, obtained from it by distillation; which are, in every respect, perfectly like the same principles yielded by other animal substances. But, if the animal that made the Urine took in with its food any of the Neutral Salts, which cannot be decomposed by digestion; that is, of those chiefly which consist of Acids and Alkalis, the Urine will contain, over and above the other parts of that animal, almost all the Neutral Salt that entered into its body. Accordingly human Urine is replete with a considerable quantity of Sea-salt, because men eat a great deal of it. It is found, after the distillation of the Urine, united with the *caput mortuum* left in the retort; because, being of a fixed nature, it doth not rise with the volatile principles in distillation.

Besides this Sea-salt, Urine contains another Salt of a singular nature, which crystallizes differently from Sea-salt. In this Salt, according to Mr. Margraff's experiments mentioned on the subject of Phosphorus, is contained the Acid necessary to produce the Phosphorus of Urine. There is reason to think that this Salt is a Sea-salt disguised by the fat matters with which it combines during its stay in the animal body.

Mr. Boerhaave calls it the Essential Salt of Urine. If you desire to have it by itself, you must evaporate the Urine with a gentle heat, to the consistence of fresh cream, filter it, and let it stand quiet in a cool place.

place. Cryftals will at length fhoot therein, and adhere to the fides of the veffels. Thefe Cryftals are the Salt you want: they are brown and oily. If you defirè to have them purer, you muft diffolve them in warm water, filter the folution, and fet it by to fhoot. This operation repeated feveral times will render them clear and transparent. Mr. Schloffer, a young and very promifing Chymift, is the laft who hath made any experiments on this curious Salt of Urine. Thofe who are defirous of a particular account of its properties may confult his differtation printed at Leyden in 1753, as well as Mr. Marggraff's excellent Memoirs printed among thofe of the Academy of Berlin.

The chief refult of Mr. Schloffer's experiments is, firft, that this Salt may be obtained from recent Urine, and even in greater quantities than from putrid Urine, and that too in very little time; feeing it cryftallizes in twenty-four hours, after due evaporation.

Secondly, that this Salt is a Neutral Ammoniaccal Salt, confifting of a Volatile Alkali, (which can never be extracted from it but in a liquid form, like that which is feparated from Urine by the addition of Lime;) and of an Acid of a very fingular nature, the moft remarkable property of which is, its being fo fixed as to refift the violence of fire, and turn into a fort of glafs rather than exhale in vapours. This is that Acid which, according to Mr. Marggraff's experiments, forms the combination of Phosphorus when united with the Phlogifton. The other properties of this fingular Acid are the principal objects of Mr. Marggraff's enquiries.

It follows, in the third place, from Mr. Schloffer's experiments, that this Acid, being combined to the point of faturacion with a common Volatile Alkali, forms a true regenerated Salt of Urine;
and

and that, by this union, the nature of the Volatile Alkali is so changed, that it cannot afterwards appear by itself in a concrete form, but is always fluid, like that which is extricated by the addition of lime.

If Fixed Alkalis be mixed with fresh Urine, they immediately separate from it a Volatile Alkali; and if the mixture be quickly put into an alembic, and distilled, the first liquor that rises is a Volatile Spirit: or else a Volatile Alkali in a concrete form will rise first, provided the Fixed Alkali made use of be not liquid, and the Urine be dephlegmated.

Herein Urine resembles other animal matters; for Fixed Alkalis produce the same effect on them. This affords us good grounds for believing that all animal matters contain a Neutral Salt of an Ammoniacal nature, which the Fixed Alkali decomposes, as it doth all other Ammoniacal Salts. Quick-lime also extricates from Urine a Volatile Alkali, still more quick and pungent than that which is separated by a Fixed Alkali, and which constantly remains liquid without ever putting on a concrete form: and this is another proof of the existence of the Ammoniacal Salt above-mentioned; for quick-lime hath just the same effect on Sal-Ammoniac, as we shall see in its place. Mr. Schloffer's experiments, compared with those now mentioned, seem to shew that the Urine contains several distinct sorts of Ammoniacal Salts.

Of all the liquors which animals afford, Urine putrefies the most easily, and by putrefaction parts with, or forms, the greatest quantity of Volatile Alkali. If it be distilled when putrefied, there comes over first a Spirit impregnated with much Volatile Alkali; then an aqueous liquor, which Van Helmont assures us is a medicine of wonderful efficacy

in dissolving the stone in the bladder. When all this water is come over, and the remaining matter is almost dry, there ascends, on increasing the fire, a yellow Oil, together with a Volatile Salt.

After this there remains in the retort a black charred earthy matter, containing a great deal of Sea-salt. If this matter be calcined in the open air, in order to consume its phlogiston, and be afterwards lixiviated, all the Sea-salt it contains may by this means be easily separated; nothing but its earth being left behind. This *caput mortuum* contains also the materials proper for forming Kunckel's Phosphorus; and if, instead of calcining it in the open air, it be urged with a violent fire, in close vessels, it will yield a Phosphorus: but then all the precautions recommended on the subject of Phosphorus must be used; and, in particular, the *caput mortuum* must be lixiviated before it be distilled, in order to free it from part of the Sea-salt contained therein; because too much of that Salt might defeat the operator, by not only melting itself, but melting also the containing vessel during the operation.

C H A P. IV.

OF THE VOLATILE ALKALI.

P R O C E S S I.

Volatile Alkalis rectified and depurated.

MIX together the Spirit, the Volatile Salt, the Phlegm, and the Oil obtained from any substance whatever. Put the whole into a large wide-mouthed glass body, and thereto fit a head with a large beak. Set this alembic in a water-bath, lute on a receiver, and distill with a very gentle heat. There will ascend a Spirit strongly impregnated with Volatile Alkali, and a Volatile Salt in a concrete form, which must be kept by itself. Then increase your heat to the degree of boiling water; whereupon there will rise a second Volatile Spirit, somewhat more ponderous than the former, with a light Oil that will swim on its surface, and a little concrete Volatile Salt. Proceed till nothing more will rise with this degree of heat. Keep by itself what came over into the receiver. At the bottom of the cucurbite you will find a thick fetid Oil.

Into such another distilling vessel put the Spirit and Salt that rose first in this distillation, and distill them in the *balneum marie* with a heat still gentler than before. A whiter, purer, Volatile Salt, will sublime. Continue the distillation till an aqueous moisture rise, which will begin to dissolve the Salt. At the bottom of the vessel will be left a phlegm,

with a little Oil floating on it. Keep your Salt in a bottle well stopp'd.

OBSERVATIONS.

IN the analysis of any substance that yields a Volatile Alkali, this Salt is generally found in the receiver, blended with the other principles of the mixt; which, ascending from the retort in the form of liquors, and vapours, dissolve the Salt, or at least moisten it, and render it very impure. So that, if you desire to have it without any mixture, recourse must be had to a second distillation, in order to separate it from the heterogeneous matters with which it is confounded.

It is of consequence in this distillation to apply but a very weak degree of heat; because on that depends the success of the operation, insomuch that the less heat you employ to sublime the Salt, the purer it will be. For, being far more volatile than any of the other principles with which it is mixed, it must evidently rise by itself, if no more heat be applied than is just necessary to elevate it; such a heat being much too weak to raise the Oil and Phlegm with which it is blended.

Nevertheless, whatever care be taken to govern the heat, it is not possible to hinder this Volatile Salt from carrying up some portions of the principles mixed with it; those, to wit, with which it is most closely united, and to which it hath by that means communicated a share of its volatility. For this reason it requires a second rectification, which is performed in the same manner as the former. But, seeing it is more volatile and lighter after the first rectification than before, being thereby freed from part of the heterogeneous matters with which it was loaded, a still less degree of heat must be applied in this second rectification.

The

The Oil with which the Volatile Salt is loaded, when but once distilled, is perceivable only by the yellow colour and weight it communicates thereto; because it is closely united therewith, and in a perfectly saponaceous state. This appears from the facility with which Volatile Salts, even the most oily, dissolve in water, without discovering in the solution any separation in the oily parts, and even without giving it a milky colour. But, in the second rectification, this Oil becomes very perceptible; for it then separates, in a great measure, from the Salt, and remains at the bottom of the cucurbite, floating on the Phlegm, which is also separated from the Salt.

The Salt is then whiter, more volatile, and purer; yet it is still far from being brought to the utmost degree of purity, even by this second rectification. It requires a third, a fourth, and even many more rectifications, to purify it perfectly: every rectification separates from it some oily particles: and if you should resolve to go on rectifying till you can separate no more Oil, there is reason to think this Salt would be entirely decomposed; because there is necessarily a certain quantity of Oil in its composition, without which it would not be a Volatile Alkali. You must therefore desist from rectifying it any further, when you find it very white, and very light; and shut it up in bottles hermetically sealed.

It often happens that Volatile Salts, though of a beautiful white after rectification, grow yellow after being kept some time in close bottles. This is occasioned by the Oil they contain disengaging and discovering itself by degrees. To remedy this inconvenience, Mr. Boerhaave proposes to mingle the Volatile Salt, which you intend to purify, with four times its weight of pulverized chalk, thoroughly dried, and even heated; to put the mixture into a

glass alembic, and distill it with a gentle heat. By this means the Salt rises exceeding pure and very white; because the chalk absorbs most of its Oil, and frees it therefrom. He adds, that Volatile Salt thus purified, may be kept a long time, and will retain all its whiteness.

If a Volatile Alkali thus purified be combined to the point of saturation, with an Acid, such as the Marine Acid for instance; the result of this union, as we shall afterwards see, will be a Sal Ammoniac, from which the Volatile Alkali may be separated by the intervention of a Fixed Alkali. A Volatile Alkali that hath passed through all these trials will then be in the highest degree of purity that Chymistry can bring it to, and appears constantly the same, from whatever substance it was originally obtained: which proves that if Volatile Alkalis, extracted from different vegetable and animal substances, seem to differ from each other in some respects, this can arise only from the heterogeneous matters with which they are mixt; but that, at bottom, they are all constituted of one single principle, which is constantly the same, and exactly alike in them all.

It is of the last consequence, on all occasions where a Volatile Alkali is to be distilled in a concrete form, to make use of subliming vessels with very large necks, that it may have room enough to make its way to the receiver with ease: for otherwise it may choak up the passage, and burst the vessels.

PROCESS II.

Volatile Alkalis combined with Acids. Sundry Ammoniacal Salts. Sal Ammoniac.

ON a Volatile Spirit or Salt pour gradually any Acid whatever. An effervescence will arise, and be more or less violent according to the nature of the Acid. Go on adding more Acid in the same manner, till no effervescence be thereby excited, or at least till it be very small. The liquor will now contain a semi-volatile Neutral Salt, called an *Ammoniacal Salt*; which may be obtained in a dry form by crystallizing as usual, or by subliming it in close vessels, after the superfluous moisture hath been drawn off.

OBSERVATIONS.

VOLATILE Alkalis have the same properties with Fixed Alkalis, fixity only excepted: so that a Volatile Alkali must produce an effervescence when mixed with Acids, and form therewith Neutral Salts, differing from each other in nothing but the nature of the Acid in their composition.

It must be observed that, on this occasion, the point of saturation is very difficult to hit, owing probably to the Volatility of the Alkali, which, being much lighter than the Acid, tends always to possess the uppermost part of the mixture; while the Acid sinks to the bottom: whence it comes to pass that the lower part of the liquor is sometimes overcharged with Acid, while the upper part is still very Alkaline. But it is most eligible that the Alkali should predominate in the mixture; because the excess of this principle easily flies off, while the moisture is evaporating, in order to the crystallization or sublimation of the Ammoniacal Salt; which

being only semi-volatile, resists the heat longer, and remains perfectly Neutral.

If the Vitriolic Acid be combined with a Volatile Alkali, and the mixture distilled in a retort to draw off the superfluous moisture, a liquor comes over into the receiver, which smells strong of a Sulphureous Acid. Now, as the Acid of Vitriol never becomes sulphureous, but when it is combined with an inflammable matter, this experiment is one of those which demonstrate that Volatile Alkalies contain a very sensible quantity of inflammable matter. This same liquor tastes of an Ammoniacal Salt; which proves that it carries up with it some of the Neutral Salt contained in the mixture. The rest of this Salt, which is called *Glauber's Secret Sal Ammoniac*, or *Vitriolic Sal Ammoniac*, sublimes into the neck of the retort. It is very pungent on the tongue; it crackles a little when thrown on a red-hot shovel, and then flies off in vapours.

The Ammoniacal Salt formed by the Acid of Nitre exhibits much the same phenomena; but it requires greater care in drying and subliming it, because it hath the property of detonating all alone, without the addition of any other inflammable matter: and it will infallibly do so, if too strong a fire be applied towards the end of the operation, when it begins to be very dry. This property of detonating by itself it derives from the inflammable matter contained in the Volatile Alkali, which serves for its basis: and this is another demonstrative proof of the existence of such an inflammable matter in the Volatile Alkali. This Salt is called *Nitrous Sal Ammoniac*.

With the vegetable Acids, that of vinegar for instance, is formed an Ammoniacal Salt of a singular nature, and which can scarce be brought to a dry form.

A Volatile

A Volatile Alkali combined to the point of saturation with the Acid of Sea-salt, forms another Neutral Salt, which takes a concrete form either by sublimation or crystallization. The crystals of this Salt are so very soft and fine, that a parcel of it looks like cotton or wool. This is the Salt properly called *Sal Ammoniac*. It is of great use in Chymistry and in manufactures: but that which is daily consumed in great quantities is not made in the manner above mentioned. It would come extremely dear, if we had no other way of procuring it, but by forming it thus with the Acid of Sea-salt and a Volatile Alkali. This Salt, or at least the materials of which it is formed, may be found in the fuliginosities and soots of most animal, and of some vegetable substances. The greatest part of what we use comes from Egypt, where vast quantities thereof are made.

The method of preparing *Sal Ammoniac* in Egypt was not known among us, till Mess. Lemaire and Granger, two of the Academy's correspondents, gave in several *Memoirs*, in which that business is described with great accuracy, from their own view on the spot. Their *Memoirs* inform us that chimney-soot alone, without any additament, is the matter from which they obtain their *Sal Ammoniac*; that those chimneys under which nothing is burnt but Cow's-dung, furnish the best soot. Six and twenty pounds of that Soot yield usually six pounds of *Sal Ammoniac*.

“ The operation takes up about fifty, or two and
 “ fifty hours. The vessels in which they put the
 “ soot are ballons of very thin glass, terminating in
 “ a neck of fifteen or sixteen lines long, and an inch
 “ in diameter; but they are not all of the same size.
 “ The least contain twelve pounds of Soot, and
 “ the greatest fifty; but they fill them only three
 C c 4 “ quarters

“ quarters full, in order to leave room for the
“ sublimation of the Salt.

“ The furnace, in which they place these ballons,
“ consists of four walls built in a quadrangular
“ form. The two front walls are ten, and the sides
“ nine foot long: but they are all five foot high,
“ and ten inches thick. Within the quadrangle
“ formed by these walls three arches run length-
“ wise, from end to end thereof, at the distance of
“ ten inches asunder. The mouth of this furnace
“ is in the middle of one of its fronts, and of an
“ oval form; two foot four inches high, and sixteen
“ inches wide.

“ The ballons lie in the spaces between the arches
“ of the furnace, which serve instead of a grate to
“ support them. Four of them are usually placed
“ in each interval; which makes sixteen for one
“ furnace. They are set at the distance of about
“ half a foot from each other, and secured in their
“ places with brick and earth. But they leave
“ about four inches on the upper part of the ballon
“ uncovered, with a view to promote the sublima-
“ tion, as they also do six inches of the inferior part,
“ that the heat may the better act on the matters to
“ be sublimed. Things being thus prepared, they
“ first make a fire with straw, which they continue
“ for an hour. Afterwards they throw in Cow's
“ dung made up in square cakes like bricks. (The
“ want of wood in this country is the reason that
“ they generally make use of this fuel.) These
“ cakes of dung add to the violence of the fire,
“ which they continue in this manner for nineteen
“ hours; after which they increase it considerably
“ for fifteen hours more; and then they slacken it
“ by little and little.

“ When the matter contained in the vessels be-
“ gins to grow hot, that is, after six or seven hours
“ baking,

“ baking, it emits a very thick and ill-scented
 “ smoke, which continues for fifteen hours. Four
 “ hours after that, the Sal Ammoniac is observed
 “ to rise in white flowers, which adhere to the inside
 “ of the neck of the vessel; and those who have the
 “ direction of the operation take care from time to
 “ time, to pass an iron rod into the neck of the
 “ ballon, in order to preserve a passage through the
 “ saline vault, for giving vent to some blueish va-
 “ pours, which constantly issue out of the vessel
 “ during the whole operation.”

From this history of the preparation of Sal Am-
 moniac it appears that Soot, and particularly the
 Soot of animal matters, either contains abundance
 of this Salt perfectly formed, and waiting only for
 sublimation to separate it therefrom, or, at least,
 that it contains the proper materials for forming it;
 and that during the operation, which is a kind of
 distillation of Soot, these materials combine together
 and sublime.

We shewed, in our analysis of Soot, that this sub-
 stance yields by distillation a great deal of Volatile
 Alkali, and this is an ingredient which makes at
 least one half of Sal Ammoniac. As to the other
 principle of this Salt, I mean the Marine Acid, this
 also must needs exist in Soot: but it is not so easy
 to conceive how it should come there.

It is very true that vegetable and animal sub-
 stances, the only ones that produce Soot in burning,
 contain some portion of Sea-salt: but then this Salt
 is very fixed, and seems unfit to rise with the Acid,
 the Oil, and the subtile Earth, of which the Volatile
 Alkali is formed. Therefore we must suppose either
 that its elevation is procured by the force of the fire,
 aided by the volatility of the matters that exhale in
 burning; or that, being decomposed by the violence
 of the combustion, its Acid alone rises with the other
 principles above mentioned. The latter seems pro-
 bable

bable enough: for though in the common operations of Chymistry the bare force of fire doth not seem sufficient to decompose Sea-salt; yet the example of Sea-plants, which, before burning, contain this Salt in abundance, and whose ashes contain scarce any at all, but are replete with its fixed part, that is, with its Alkaline basis, seems to prove that, when this Salt is intimately mixed with inflammable matters, it may be destroyed by burning; so that its Acid shall desert its basis, and fly off with the Soot.

Before the exact method of procuring Sal Ammoniac was known, it was generally imagined that the manufacturers mixed Sea-salt, and even Urine, with the Soot; because these two substances contain the principles of which this Salt consists. But, besides that the contrary now certainly appears from the above-mentioned Memoirs, it hath been shewn by Mr. Duhamel, who hath published several Memoirs and Experiments concerning the composition and decomposition of Sal Ammoniac, from which we have partly taken what we have already said on this subject, and which will furnish us with some more curious observations; it hath been shewn, I say, in the first of Mr. Duhamel's Memoirs, printed with those of the Academy for 1735, that the addition of Sea-salt to the Soot, from which Sal Ammoniac is to be extracted, contributes nothing to its production, and cannot increase its quantity. That alone, therefore, which was originally contained in the matters that produced the Soot, enters as a principle into the composition of Sal Ammoniac. We observed also, in treating of the analysis of Soot, that Boerhaave obtained from it a considerable quantity of an Ammoniacal Salt without any additament.

Sal Ammoniac is sometimes found perfectly formed in the neighbourhood of Vulcanos. This

Salt is probably produced from the fuliginosities of vegetable or animal matters consumed by the fire of the Vulcano.

Sal Ammoniac is often impure, because it carries up with it, in sublimation, some of the black charred matter which ought to be left at the bottom of the vessel: but it is easily purified. For this purpose you need only dissolve it in water, filter the solution, then evaporate and crystallize; by which means you will have a very white and very pure Sal Ammoniac. You may, if you please, sublime it again in a cucurbite and blind head, with a fire not too brisk. Some of it will rise in the form of a light white powder, called *Flowers of Sal Ammoniac*. These Flowers are no other than true Sal Ammoniac, which hath suffered no decomposition; because the bare action of fire is not capable of separating the Acid and the Volatile Alkali, of which this Neutral Salt consists. When you intend to decompose it, you must use the means to be mentioned hereafter.

Though Sal Ammoniac be only semi-volatile, and requires a considerable heat to sublime it, yet it hath the property of carrying up with it matters that are very fixed and ponderous; such as metallic substances, and some kinds of earths. For medicinal uses we sublime therewith Iron, Lapis Hæmatites, the Copper in blue Vitriol, &c. and then it takes different names, as *Martial Flowers of Sal Ammoniac*, *Ens veneris*, and other such denominations, which it borrows from the matters sublimed with it.

PROCESS III.

Sal Ammoniac decomposed by Acids.

IN TO a large tubulated glass retort put a small quantity of Sal Ammoniac in powder: set your retort in a furnace, and lute on a large ballon, as in the distillation of the smoking Acids of Nitre and Sea-salt. Through the hole in your retort pour a quantity of Oil of Vitriol or Spirit of Nitre, equal in weight to your Sal Ammoniac. An effervescence will instantly follow. The mixture will swell, and discharge white vapours, which will come over into the receiver. Stop the hole in the retort immediately, and let the first vapours pass over, together with some drops of liquor, which will distill without fire. Then put a few coals into the furnace, and continue the distillation with a very gentle heat; which however must be increased, little by little, till nothing more will come off. When the operation is finished, you will find in the receiver a Spirit of Salt, if you made use of Oil of Vitriol; or an *Aqua regis*, if Spirit of Nitre was employed; and in the retort will be left a saline mass, which will be either a Glauber's Secret Sal Ammoniac, or a Nitrous Sal Ammoniac, according to the nature of the Acid used to decompose the Sal Ammoniac.

OBSERVATIONS.

SAL Ammoniac, which consists of the Marine Acid united to a Volatile Alkali, is, with respect to the Vitriolic and Nitrous Acids, just the same as Sea-salt is with respect to those Acids; that is, the Vitriolic and Nitrous Acids, having a greater affinity, than the Marine Acid, with Volatile as well as Fixed Alkalis, will decompose the Sal Ammoniac, by expelling the Acid from its basis, and as-
fuming

fuming its place, just as they do with regard to Sea-salt. Most therefore of what was said concerning the decomposition of Sea-salt, and the distillation of its Acid, by the two other Acids, must be applied here.

We shall only observe, that, when the Acid of Sal Ammoniac is to be distilled from it by the interposition of the Vitriolic or Nitrous Acid, great care must be taken to put but a very small quantity of this Salt into the retort; especially if the Acids to be added are concentrated; for, as soon as they mix with the Sal Ammoniac, a great effervescence arises, and the mixture swells to such a degree, that, unless the quantity in the retort be very small, it may run over all together into the receiver. It is also proper to take notice that this operation admits of but a small degree of heat, for two reasons; first, because the Acid of the Sal Ammoniac, being very easily dislodged by an Acid stronger than itself, rises also very easily; secondly, because the Sal Ammoniac which is to be decomposed, as well as the Ammoniacal Salts which result from its decomposition, are semi-volatile, and will sublime in substance if they be exposed to the smallest excess of heat. Moreover, the Nitrous Sal Ammoniac would be in danger of taking fire and exploding, for a reason frequently mentioned above.

The Nitrous Sal Ammoniac may be decomposed, as well as Sal Ammoniac, by the Vitriolic Acid. But, as the Nitrous Acid contained in the Salt is the strongest of all Acids, next to the Vitriolic, no other Acid but this is able to expell it from its basis; in which respect this Salt resembles Nitre.

Instead of employing the Acids of Vitriol and Nitre to decompose Sal Ammoniac, we might make use of Neutral Salts consisting of these Acids combined with metallic or earthy bases: but then,

as this decomposition cannot be effected without a greater degree of heat, there is reason to apprehend that some of the Sal Ammoniac would be thereby sublimed, before it could be decomposed.

P R O C E S S I V.

Sal Ammoniac decomposed by Fixed Alkalis. Volatile Salt. The Febrifuge of Sylvius.

INTO a glass alembic or retort put Sal Ammoniac and Salt of Tartar, pulverized and mixed together in equal quantities. Set your vessel in a proper furnace, and immediately lute on a large receiver. A little Volatile Spirit will ascend; and a Volatile Alkali in a concrete form, very white and beautiful, will sublime into the head, and come over into the receiver, in quantity of near two thirds or three fourths of the Sal Ammoniac used. Continue the distillation, increasing the fire by degrees, till nothing more will sublime. Then unlute the vessels. Put up your Volatile Salt immediately into a wide-mouthed bottle, and stop it close with a crystal stopple. At the bottom of the retort, or cucurbite, you will find a saline mass, which, being dissolved and crystallized, will form a Salt nearly cubical, having the taste and other properties of Sea-salt. This is the *Sal Febrifugum Sylvii*.

O B S E R V A T I O N S.

THIS decomposition of Sal Ammoniac is the reverse of that in the preceding process. In the former operation it was shewn that the Acid of Sal Ammoniac may be separated from its basis, by applying to that basis a stronger Acid: in the present operation, on the contrary, the basis of this Salt is separated from its Acid, by presenting to that Acid
a Fixed

a Fixed Alkali, wherewith it hath a greater affinity than with the Volatile Alkali which serves it for a basis.

The action of Fixed Alkalis upon Sal Ammoniac is so vigorous and sudden, that, as soon as these two matters are mixed together, the Volatile urinous Salt rushes out with great activity, even without the help of heat; so that much of it will be lost, if care be not taken to confine the mixture immediately in those vessels by means of which it is to be distilled.

The Volatile Salt obtained by this operation is white, pure, and very active; having been freed from the greatest part of its superfluous fat matter, both by the union it had contracted with the marine Acid, and by the Fixed Alkali employed to separate it therefrom. This Salt is so quick and volatile, that if, on taking it out of the receiver, it be left a little too long exposed to the air, before it be put into the bottle in which it is to be kept, a great deal of it will exhale and be lost. For the same reason care should be taken, while the vessels are unluting, that the vapour of this Salt do not strike the organ of smelling, or be drawn into the lungs in respiration; for it affects those organs so powerfully, and makes such a quick impression on them, that the operator would be in danger of suffocation. Yet it is of great service, when cautiously smelled to, for exciting the vibrations of the *Genus Nervosum*, in Apoplexies, Fainting Fits, and Hysterical disorders. But it must always be administered with great caution; for it hath a corrosive quality, and is no less caustic than a Fixed Alkali. This is proved by applying it to the bare skin, and keeping it on by means of a pitch plaster, so that it cannot fly off in vapours: for, as soon as it begins to grow warm, it produces on the skin a smarting sensation, like that
of

of burning, attended with much pain, and in a very short time makes an eschar like a caustic.

The Volatile Spirit obtained in the decomposition of Sal Ammoniac by a Fixed Alkali, derives its origin from the Phlegm contained in the saline matters that are mixed together on that occasion. The moister those matters are, the more Spirit there will be. This also is very active and penetrating. But as it owes these qualities wholly to the Volatile Salt dissolved in it, the more of this Spirit comes off, the less Salt will there be.

If you desire to have much Volatile Spirit, a quantity of water, proportioned to the quantity of Spirit you want, must be mixed with the Salts. In this case the distillation begins with a humid vapour, which coagulates on the sides of the receiver into a concrete Salt, almost as soon as it comes over. There rises afterwards an aqueous vapour, not so saline or volatile as the former. This liquor dissolves the Salt that was coagulated before; and, if the water added was in sufficient quantity, it will dissolve the Salt entirely; otherwise it will dissolve but a part thereof, and then it is certain that the liquor is a Volatile Spirit as strongly impregnated with Salt as it can be. The reason why the liquor that rises first contains a great deal more Volatile Salt than the other, inasmuch that it coagulates and becomes solid, is because the Volatile Salt rises in distillation much more easily than water.

In whatever manner the Volatile Spirit or Salt be distilled from Sal Ammoniac, by means of a Fixed Alkali, we always find at the bottom of the retort, or cucurbite, when the operation is finished, a new Neutral Salt compounded of the Acid of the Sal Ammoniac, and of the Alkali used in the distillation. If the Salt of Tartar be used, this new Neutral Salt will be perfectly like that produced by

combining this Alkali with the Acid of Sea-salt, to the point of saturation. The figure of the crystals of this Salt, though much like that of the crystals of Sea-salt, is nevertheless a little different. However, this Salt possesses the chief properties of Sea-salt. It bears the name of *Sal Febrifugum Sylvii*, because that Physician attributed to it the virtue of curing intermitting fevers. But its title to this virtue is very doubtful, at least in this country.

If the Salt of Soda be used instead of Salt of Tartar, to decompose Sal Ammoniac, a Volatile Spirit and Salt will in like manner be obtained; and the Neutral Salt left in the retort after distillation, will be a true regenerated Sea-salt, perfectly like native Sea-salt: because, as we have said before, the Salt of Soda is of the same kind with the natural basis of Sea-salt; and the inconsiderable differences, observable between the *Sal Febrifugum* and Sea-salt, can be attributed only to such as may be found between the Alkaline basis of those two Salts.

PROCESS V.

Sal Ammoniac decomposed by Absorbent Earths and Lime. The Volatile Spirit of Sal Ammoniac. Fixed Sal Ammoniac. Oil of Lime.

LET one part of Sal Ammoniac, and three parts of Lime, flaked in the air, be pulverized separately, and expeditiously mixed together. Put this mixture immediately into a glass retort, so large that half of it may remain empty. Apply thereto a capacious receiver, with a small hole in it to give vent to the vapours, if needful. Let your retort stand in the furnace about a quarter of an hour, without any fire under it. While it stands thus, a

great quantity of invisible vapours will rise, condense into drops, and form a liquor in the receiver. Then put two or three live coals in your furnace, and gradually increase the fire till no more liquor will rise. Now unlute your vessels, taking all possible care to avoid the vapours, and quickly pour the liquor out of the receiver into a bottle, which you must stop with a crystal stopple rubbed with emery. There will remain, at the bottom of the retort, a white mass, consisting of the Lime employed in the distillation, together with the Acid of the Sal Ammoniac: this is called *Fixed Sal Ammoniac*.

OBSERVATIONS.

IN our Elements of the Theory, we explained how we imagine that Lime and other substances, which, according to the Table, have less affinity than Volatile Alkalis with Acids, are nevertheless capable of decomposing Sal Ammoniac, by uniting with its Acid, after expelling it from its basis, which is a Volatile Alkali. To recapitulate our opinion in two words: we conceive this to depend on the fixedness of these earthy and metallic additaments, which enables them to resist the force of fire, and on the volatility of the basis of Sal Ammoniac, which proves a great disadvantage to it when it comes to struggle, as it were, with these fixed additaments, aided by a considerable degree of heat. We shall only observe, that we are not singular in this opinion, nor indeed did we deliver it as a new one; that several modern Chymists concur with us therein, and particularly Mr. Baron, whom we have already mentioned more than once on the subject of Borax; and who, we think, was the first that ever took particular notice of it in print, viz. in his Memoirs on Borax, communicated to the Academy before the publication of our Elements. For the explanation of this phenomenon, therefore, we refer
to

to those Memoirs, which are actually published, and to what we have already said on the subject in our treatise above mentioned.

Another phenomenon, which is equally singular and curious, furnishes us with matter for several reflections, and gives us occasion to relate, in few words, the result of Mr. Duhamel's most sagacious experiments and speculations tending to discover the cause thereof. The point under consideration is the different forms and properties which the Volatile Alkali assumes, when separated from Sal Ammoniac by the means of a Fixed Alkali, and by the means of Lime. We know that the former is always in a concrete form, unless the mixture, from which it is distilled, be absolutely drenched with water; and that the latter, on the contrary, is always in a fluid form, and constantly liquid, whatever method be taken to distill it.

Some Chymists imagine that the Volatile Salt of Sal Ammoniac appears in a concrete form, only because it still contains some Acid; whence they conclude that the reason why no concrete Volatile Salt can be obtained by the means of Lime is, because it absorbs all the Acid of the Sal Ammoniac; which is not the case, they say, with Fixed Alkalis. Others impute the constant fluidity of the Volatile Spirit of Sal Ammoniac, obtained with Lime, to the particles of fire which they suppose communicated thereto by that substance. Mr. Duhamel equally refutes both these opinions, by proving from experiments that Fixed Alkalis are capable of absorbing as much Acid as Lime can, and even more; and that, having been calcined as long, and with as violent a fire, as Lime, they must contain and communicate as many particles of fire; if indeed, it be possible that the particles of fire should actually be lodged, and continue imprisoned, in calcined substances, as these gentlemen suppose. Yet this is con-

trary to experience; seeing the Volatile Salt distilled by the means of a Fixed Alkali, though ever so long and ever so violently calcined, is always in a concrete form, and doth not resemble the Volatile Spirit of Sal Ammoniac prepared with Lime.

In order to throw the necessary lights on this point, Mr. Duhamel had recourse to the only method that can be depended on in Natural Philosophy; namely, Experiments. He accordingly made several, of which these are the chief.

First, he distilled a Volatile Salt, by the means of well desiccated Salt of Tartar, and Salt of Soda; and, urging the fire with great violence towards the end of the operation, he thus obtained a quantity of Volatile Salt equal to, or even exceeding, that of the Sal Ammoniac he used: whence he justly concluded, that, on this occasion, the Volatile Salt carried up and volatilized some of the Fixed Salt.

Secondly, he found upon trial that the Volatile Spirit, obtained from Sal Ammoniac by the means of Lime, appears in the form of a liquor, only because it is mixed with some water which was contained in the Lime. Of this truth he had the following decisive proof: having attempted to prepare a Volatile Spirit of Sal Ammoniac with Lime, which had not been slaked, either in the air or by water, he could not obtain any Volatile Spirit; or, at least, the quantity was so small that it might be reckoned as nothing; and even that was wholly due to the moisture which Sal Ammoniac necessarily contains, together with that which Lime imbibes from the air, if ever so little exposed thereto.

From these two Experiments Mr. Duhamel draws the following consequences: viz. that the Volatile Salt cannot be separated from the Sal Ammoniac and sublimed, without carrying along with it some of the additament which serves to extricate it; or, instead thereof, some other body with which it

it is capable of uniting: that Fixed Alkalis have the property of thus being carried up by the Volatile Alkali, and subliming with it: that the case is not the same with Lime, which therefore cannot, when alone, separate and sublime the Volatile Alkali of the Sal Ammoniac; but becomes capable thereof when it hath imbibed any moisture, which joins with the Volatile Salt, and rises therewith in distillation. And hence it must be concluded, that, seeing the Volatile Salt carries up with it some of the Fixed Alkali, by the means of which it is separated, it will be in a concrete form; what it carries up along with it being dry and solid: whereas, when it is distilled with Lime, it cannot but be liquid; seeing it must needs be dissolved by the moisture it gets from the Lime, without which it would not rise.

But to what must we attribute these effects produced by Lime, so different from those produced by Fixed Alkalis? Are they owing to its quality of Lime? Or would it produce the same, if it were only a mere Absorbent Earth? Mr. Duhamel hath answered this question by a third sort of experiment. He tried to decompose Sal Ammoniac, and to separate its Volatile Alkali, by a pure Absorbent Earth, without mixing any water with it, or calcining it.

For this purpose he made use of Chalk; and his experiment succeeded. By means of this additament he decomposed Sal Ammoniac, and by the experiment obtained the lights he wanted. The Volatile Alkali, being extricated by the dry but uncalcined Chalk, rose in a concrete form, as with Fixed Alkalis; and in like manner carried up with it some of the earthy additament. The same Chalk when calcined, and converted into Lime, produced the very effect of Lime on Sal Ammoniac. It is therefore from calcination alone that Absorbent

Earths derive the property of retaining obstinately the Volatile Alkali, and preventing its sublimation by refusing to rise with it as Fixed Alkalis do.

Though these ingenious experiments evidently furnish us with great lights, for discovering the cause of the solidity or fluidity of the Volatile Alkali, when separated from Sal Ammoniac by different additaments, as they fully determine several preliminary questions immediately relating thereto; yet they still leave us, in some measure, at a loss with regard to the chief point. For we do not yet know why Fixed Alkalis and Absorbent Earths, which, in all Chymical trials, shew that they have certainly as much fixity as Lime, are carried up by the Volatile Alkali, while Lime resists, instead of rising with it as those other substances do, obstinately retains it, and even fixes it in some measure, so that it is impossible for it to sublime. This question, in my opinion, depends on the theory of Lime; nor can we hope to resolve it, in its full extent, till we get a further insight into the nature of that singular substance than we have at present.

On this subject, however, Mr. Duhamel hath offered some conjectures founded on the known properties of Lime, and supported by experiments. "Lime," says he, "is an Earth freed by calcination from almost all its humidity, almost all its Acid, and all the Fat it contained; whether that fat came from some animal parts, as is the case of those stones which consist of shells; or whether it were a bituminous fat, as may happen to be the case with some others: this substance is withal acrid and fiery; it is very greedy of moisture, and imbibes it when exposed thereto. It absorbs Acids, and retains them strongly; and, lastly, it unites with fat matters, and therewith makes a kind of soap."

All the properties are verified by experiments; and therefore Mr. Duhamel thinks he hath a right to say, that Lime acts not only on the Acid of Sal Ammoniac, but also on the fatty matter which always accompanies Volatile Alkalis, and is essential to their nature; and therefore it decompounds them. Of this Mr. Duhamel gives the following convincing proof, founded on experiment. He took some Volatile Spirit distilled with Lime, and abstracted it several times from a fresh parcel of Quick-Lime. The quantity of the Spirit diminished sensibly every time; and the Lime was at last so replete with fat, that the Vitriolic Acid, when poured thereon, became very sulphureous; and moreover, when calcined in a crucible, it emitted a very perceptible smell of burnt grease.

Indeed Fixed Alkalis are also capable of absorbing and retaining fat matters; but not near so strongly as Lime: because these Salts are never entirely freed from that which they contain originally; whereas Lime seems much poorer, and absolutely void of any oily matter.

On these principles Mr. Duhamel resolved to try if he could not obtain a Volatile Alkali in a concrete form, by distilling the Volatile Spirit from Lime, brought nearly to the condition of a Fixed Alkali, by imbibing a portion of fat matter. With this view he distilled a great quantity of Volatile Spirit from a little Lime, and actually obtained a small portion of Volatile Salt; because the great quantity of Volatile Spirit had in some measure saturated the Lime with fat matter.

Mr. Duhamel tried also to bring Lime back to the condition of a pure Absorbent Earth, to *decalcine* it, if I may use the term; in order to try whether he could not by this means make it produce the same effect as Chalk. For this purpose he lixiviated some Lime four months successively,

pouring every day fresh water on it, and removing that of the preceding day, together with the crystalline crust which always formed on it; and after leaving this Lime two years in the shade, he applied it to Sal Ammoniac. It produced a moderate quantity of Volatile Salt, which was very transparent and seemed to be crystallized in cubes. Thus we see Lime rendered very like Chalk. Yet it was pretty acrid on the tongue, and the Volatile Salt, obtained by its means, was more disposed to run into a liquid than that separated by Chalk: which shews that this Lime still retained some part of its former character, and that its transformation was not complete.

To conclude what relates to the Volatile Alkali of Sal Ammoniac, it only remains that we say a word or two of that portion of the earthy or saline additament, which, though fixed in its nature, sublimes nevertheless with the Volatile Alkali, and gives it a concrete form.

Mr. Duhamel, who, in every subject that he handles, omits nothing worthy of attention, made several other experiments, with a view to discover whether or no the Salt of Tartar, and the Chalk, carried up by the Volatile Alkali, be truly volatilized; and whether or no there be such a strict union contracted, between the Urinous Salt and these fixed substances, that the whole results in what is called a *Concrete Volatile Salt*; or if those fixed substances be united but superficially with the Urinous Salt, which only carries them up along with itself in sublimation, as Sal Ammoniac carries up several very fixed metallic matters.

The result of the experiments made by Mr. Duhamel for this purpose is, that the fixed substances carried up by the Volatile Alkali of the Sal Ammoniac are actually volatilized; that they make, as it were, one whole with it; and are so closely combined

bined therewith, that almost all the most efficacious means of separating fixed from volatile matters are unsuccessful with regard thereto. Nothing, for instance, is fitter to separate a volatile substance from a fixed one, than to mix the compound with a great quantity of water, and to distill the whole, with such a degree of heat as shall be exactly sufficient to elevate the volatile part. In this manner Mr. Duhamel treated Volatile Alkalis replete with Fixed Salt, and with Chalk : but though he applied no more than the gentlest degree of heat ; nay, exposed his mixture to the air only, fearing lest he should make the heat too strong if he used fire ; yet the fixed part, which the Volatile Salt had carried up with it, continued still united therewith ; so that the whole passed over in distillation, or was dissipated by evaporation, without leaving any thing fixed at the bottom of the vessel.

He also justly looked on Acids as an effectual means of procuring the separation, or decomposition, he was in quest of. We know that, with the Volatile Alkali, they form Ammoniacal Salts, which, though they are not so light as the Volatile Alkali, sublime nevertheless with a moderate heat ; and that, on the contrary, the same Acids, with Fixed Alkalis, or Absorbent Earths, form Neutral Salts, which resist the violence of fire. On this principle Mr. Duhamel poured Acids, to the point of saturation, upon Volatile Alkalis containing much Fixed Alkali, or Chalk. But this experiment succeeded no better than the foregoing ; for the mixture being put to distill, sublimed wholly in Sal Ammoniac. Indeed a little fixed matter was left at the bottom of the retort : but the quantity thereof was too small to merit notice.

At last, the only way Mr. Duhamel could think of, for separating, from a Concrete Volatile Alkali, the fixed parts which that Salt had rendered volatile,

was

was to expose it to the air, covered with a piece of gauze only; but in its dry state, without dissolving it in water. The Volatile Urinous Salt was by this means dissipated; having deserted the fixed part, which remained at the bottom of the basin, and, being exposed to the fire, retained its fixed nature. But it took more than a year to effect this separation; nor are we sure that it was complete; for it is not certain that all the fixed part was left behind, and that some of it was not dissipated with the Volatile Urinous Salt.

This volatilization, this kind of metamorphosis of a Fixed Alkali and an Absorbent Earth into a Volatile Alkali, is a very curious phenomenon, and deserves to be considered by the best Chymists.

We shall finish our observations on the decomposition of Sal Ammoniac by Lime, with some reflections on the nature of the *caput mortuum* that remains after this distillation.

This residuum is only Lime impregnated, but not saturated, with the Acid of Sea-salt. If the distillation be urged at last with a violent fire, the *caput mortuum* will be found formed into a mass, seeming to have been half-melted. This matter is a kind of Phosphorus, and emits light in the dark, when struck with any hard body. Mr. Homberg was the first who discovered it to have this property. Having calcined, and melted together, in a crucible, one part of Sal Ammoniac and two parts of Lime, with a design to fix that Salt, he observed the mass remaining after the fusion to have the property just mentioned.

Lime, thus impregnated with the Acid of Sal Ammoniac, is very improperly called by the name of *Fixed Sal Ammoniac*. This compound attracts the moisture of the air, and even runs wholly into a liquid, if it be impregnated with much Acid. It hath almost all the properties of Fixed Alkalis.

This liquid is called *Oil of Lime*, for the same reason that deliquated Salt of Tartar is called *Oil of Tartar*.

P R O C E S S VI.

Volatile Alkalis combined with Oily matters. A Volatile Oily Aromatic Salt.

PULVERIZE and mix together equal parts of Sal Ammoniac and Salt of Tartar : put the mixture into a glass or stone cucurbite : pour on it good Spirit of Wine, till it rise half an inch above the matter. Mix the whole with a wooden spatula ; apply a head and receiver, and distill in a sand-bath, gently heated, for two or three hours. A Volatile Salt will rise into the head ; and then the Spirit of Wine will distill into the receiver, carrying with it a portion of the Volatile Salt.

When nothing more will come over, let your vessels cool, then unlute them, separate the Volatile Salt, and weigh it directly. Return it into a glass cucurbite, and for every ounce thereof add a dram and a half of Essential Oil, drawn from one or more sorts of aromatic plants. Stir the whole with a wooden spatula, that the Essence may incorporate thoroughly with the Volatile Salt. Cover the cucurbite with a head, fit on a receiver, and, having luted it exactly, distill in a sand-bath, as before, with a very gentle heat. All the Volatile Salt will rise, and stick to the head. Let the fire go out, and when your vessels are cooled, take your Salt out of the head. It will have an odour compounded of its own proper smell, and the smell of the Essence with which it is combined. This is an *Aromatic Oily Salt*. Put it into a bottle stopped close with a crystal stopple.

OBSERVATIONS.

THE design of this operation is to incorporate and unite an Oil with a Volatile Alkali. Spirit of Wine is added in the distillation of the Volatile Salt, intended for this purpose, in order to prepare it for receiving the Oil, and combining more easily therewith. This Salt hath the property, as was shewn in the preceding operation, to carry up with it part of the substances with which it is distilled. On this occasion, therefore, it is impregnated with a little of the Spirit of Wine; and this Spirit, which contains in itself an oily matter, and is the solvent of Oils, cannot fail to facilitate the union of the Oil with the Volatile Salt, as it serves for a medium between them. Yet it must not be considered as a necessary one. A Volatile Salt, sublimed with Salt of Tartar alone, would also very readily take up any Oil with which it should be distilled. We have seen that Volatile Alkalis are originally impregnated with much Oil, which is radically dissolved in them; and consequently they have a great affinity with that substance. So that if we distill them with Spirit of Wine, at the beginning of this operation, we do it not out of any necessity, but only with a view to accelerate or facilitate the intended union.

In this distillation the Volatile Alkali always rises first, and before the Spirit of Wine; which proves that it is much more volatile, though it be more ponderous than the Spirit.

If the Spirit of Wine used in this distillation be very aqueous, it will dissolve the Salt as it comes over, and will reduce it into a Spirit; but if, on the contrary, it be well dephlegmated, the Volatile Alkali will remain in a concrete form, and will not be dissolved in this first distillation.

If you desire to have the Volatile Salt entirely dissolved in the Spirit of Wine, though highly dephlegmated,

phlegmated, it must be repeatedly distilled a great number of times with the same Spirit of Wine; for, though the small quantity of Spirit of Wine with which it unites in the first distillation, be not capable of reducing it into a liquid, yet, as it takes up more and more every time it is distilled, it dissolves at last, and then with the Spirit of Wine forms a fluid that appears perfectly homogeneous. The Volatile Alkali is now rendered considerably milder by the union thus contracted, and is accordingly called the *Dulcified Volatile Spirit of Sal Ammoniac*.

When well-dephlegmated Spirit of Wine is mixed with a Volatile Spirit of Sal Ammoniac, perfectly saturated with Volatile Salt, these two liquors together immediately form a white opaque *coagulum*. But for this purpose you must not use a Volatile Spirit distilled with Lime; for then the experiment will not succeed.

This *coagulum* does not seem to be the effect of an intimate union between the two substances mixed together, like that which results from the union of a Fixed Alkali with an Oil. It hath just now been shewn that Spirit of Wine and a Volatile Alkali do not readily unite together. I believe the effect rather depends on this, that Spirit of Wine hath a greater affinity than the Volatile Salt with water; and therefore the Spirit, which ought to be perfectly dephlegmated, attracts the water wherein the Volatile Salt was dissolved, which thereupon recovers its concrete form; and being at that time mixed with the Spirit of Wine, it keeps that Spirit locked up among its parts, and hinders it from appearing with its natural fluidity.

What confirms this notion is, that the *coagulum*, which at first seems to make but one whole, soon separates into two parts, whereof one, which is solid, and nothing but the Volatile Salt concreted, lies at the bottom of the vessel; and the other, which is fluid,

fluid, cannot be mistaken for any thing but the Spirit of Wine, which, being disengaged from the particles of Salt, recovers the form of a liquid, and, being the lightest, floats over the Salt. Yet these two substances, though now very distinct from each other, are not so pure as before they were mixed together. The Spirit of Wine hath dissolved a little of the Volatile Salt; and, on the other hand, the Volatile Salt retains a little of the Spirit of Wine. They may indeed be perfectly united and blended with each other, by the method above delivered; that is, by being frequently distilled and cohobated together, till they form one mixt; but then that mixt will be in a liquid form.

The first time this mixture is distilled, a great deal of Volatile Salt rises first, which is very fit to unite with an Essential Oil, and so to become a Volatile Oily Aromatic Salt.

THE END.

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Varnish	_____	i. 115. ii. 266.
Vegetable Salt	_____	i. 126. ii. 282.
Verdegriſ	_____	i. 123. ii. 319.
distilled	_____	ii. 318.
Vermillion	_____	i. 82.
Vinegar	_____	i. 120. ii. 282, 300.
distilled	_____	i. 121.
concentrated	_____	ii. 304, 312.
analyzed	_____	ii. 308.
Vinous Fermentation	_____	i. 111. ii. 220, 224.
Vitriol, Blue	_____	i. 61, 148, 213, 223, 355.
Green	_____	i. 66, 148, 211, 223.
White	_____	i. 95, 223. ii. 68.
extracted from the Pyrites	_____	i. 210.
of Lead	_____	i. 392.
Vitriolated Tartar	_____	i. 25, 224, 254, 257.
Vitriolic Acid	_____	i. 23.
concentrated	_____	i. 233.
		Volatile





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